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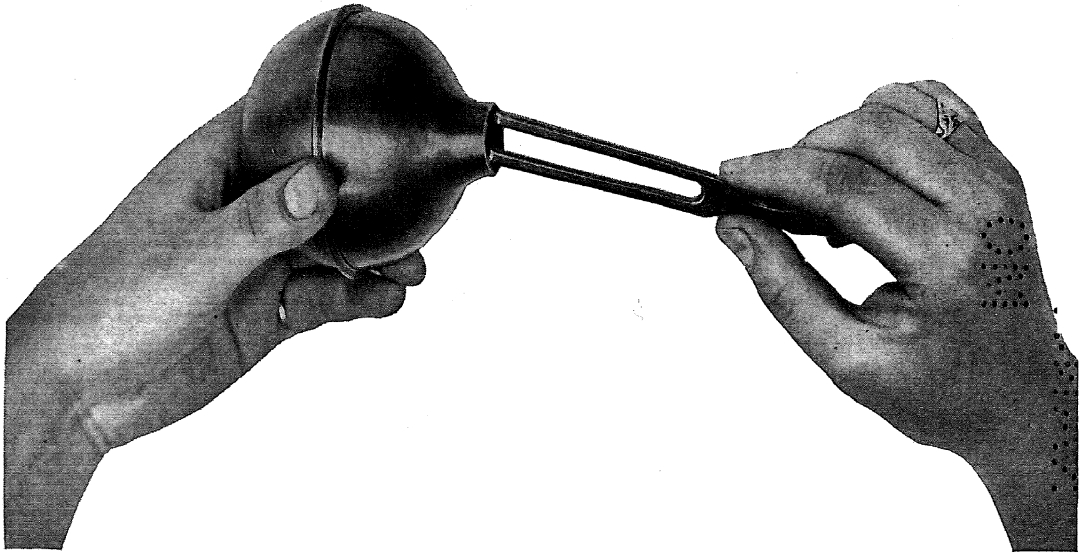

A striking demonstration of resonance—the most important factor in voice production.

The air in the resonator amplifies the tone of the fork at least two hundredfold.

THE NATURAL METHOD OF VOICE PRODUCTION

IN SPEECH AND SONG

BY

FLOYD S. MUCKEY, M.D.C.M.

ILLUSTRATED

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NEW YORK CHICAGO BOSTON

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TO

THE LATE PROFESSOR WILLIAM HALLOCK,
WITHOUT WHOSE EFFICIENT CO-OPERATION
THIS INVESTIGATION COULD NOT HAVE BEEN
CARRIED TO ITS SUCCESSFUL CONCLUSION

PREFACE

At the request of Professor S. H. Clark, Professor of the Department of Public Speaking at the University of Chicago, Chicago, Illinois, Professor John M. Clapp, Professor of English at Lake Forest University, Lake Forest, Illinois, and many others, the author has decided to put his views on voice production into book form.

The fact that the study of voice production requires a knowledge of physics as well as of anatomy and physiology led to the collaboration of the late Professor William Hallock, Professor of Physics at Columbia University, and the author in what they agreed should be a strictly scientific investigation of the voice mechanism. Up to the time when this investigation began, the study of physics had been Professor Hallock's chief occupation. The same statement applies to the author's study of anatomy and physiology, especially

taught in class than individually. Pupils thus learn to recognize interference in other voices, which aids them materially in criticising their own production. Teaching in class makes it practicable to apply the natural method in public-school work. The only possible means of improving the American-speaking voice, which is notoriously bad, is through our public schools.

If the natural quality of the human voice could be reproduced for students by means of a phonograph, this would be an ideal way of demonstrating the correct use of the voice mechanism. In this way the exercises for voice development could be impressed upon records by the advanced students of the natural method and reproduced for the benefit of teachers and pupils. However, the present methods of recording and reproducing voice tones are such that the higher overtones are strongly impressed upon the record, while the fundamental tone remains relatively weak. The same principle is used in reproducing. The result is that the ideal voice tone, which requires the presence of a strong fundamen-

tal, cannot be secured by the use of the present phonograph.

A method of recording and reproducing voice tones has, however, been devised which will make this use of the phonograph feasible. In the meantime, the use of the tuning-fork and resonator will give the teachers and pupils a very good idea of the quality of the strong fundamental tone.

The credit for the invention and construction of the various forms of apparatus, without which this investigation could not have been brought to a successful termination, belongs largely to the late Professor Hallock. He was a man of wide experience and broad knowledge. He possessed great mechanical skill and inventive genius and a resourcefulness which especially fitted him to surmount the countless difficulties which presented themselves. For these reasons, the author feels that he, in common with every other voice student, owes Professor Hallock a debt of gratitude which can hardly be measured.

The author wishes to thank Mr. A. Mercer Parker for his valuable assistance in the ar-

rangement of the subject-matter and for his careful and suggestive revision of the manuscript, which have produced a betterment which gives him almost a tenant-right in these pages.

If this book succeeds in lessening the number of voices ruined by false methods, and aids in the improvement of the American speaking and singing voice, the author will feel amply rewarded.

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THE NATURAL METHOD OF VOICE PRODUCTION

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CHAPTER I

PRELIMINARY CONSIDERATIONS

A COMPLETE investigation of voice production involves two steps: first, a study of the voice itself or the various combinations of air-waves which affect the auditory mechanism of the listener; second, an inquiry into the action of the mechanism which produces the voice. The first part of this investigation lies in the field of physics; the second part is found in the province of anatomy and physiology. From 1879 to 1893 the present writer made a careful and continuous study of the anatomy and physiology of the voice mechanism in its relation to voice production. After about ten years of this time had elapsed, interspersed

with periods of study with some of the leading voice teachers of this country, the writer became convinced that the problem of correct voice production could not be solved by a consideration of anatomy and physiology alone. Then began a course of reading on the physics of sound production which resulted in the conclusion that nothing but an analysis of the voice itself could definitely determine the correct action of the voice mechanism. This was the problem which the author brought to the late Professor William Hallock, professor of physics at Columbia University, January 1, 1893. We immediately began what we agreed should be a strictly impartial scientific investigation of the action of the voice mechanism from the standpoint of anatomy (structure of the mechanism), physiology (function of the various parts of this mechanism), and physics (laws which regulate its action).

After perfecting the apparatus for voice analysis described in Chapter IV we photographed thousands of voices, ranging from voices of such caliber as Jean and Edouard

de Reszke's, Nordica's, Scalchi's, Calvé's, and others of equal prominence, to those of the veriest tyros in the field of voice production.

We then studied so far as possible the structure and action of the mechanisms which produced these various voices. Many interesting and valuable discoveries resulted from this study. Among the most important of these was the fact that the voice mechanism is a stringed instrument, which was contrary to the statements of all writers up to that time, including such prominent physicists as Helmholtz, König, Tyndall, and others. This discovery is fully explained in Chapter V on "Pitch."

Having established this fact, we reasoned that the vocal apparatus should include a mechanism for changing the length, weight, and tension of the vibrator (vocal cords) similar to that found in other stringed instruments. This led to a discovery of the correct action of the "vocal muscle" (*thyro-arytenoideus*), and the crico-thyroid muscle in pitch changes. This is also explained in Chapter V.

As these studies progressed, the impression that resonance is the determining factor in both volume and quality forced itself upon us. We began to investigate the question of resonance as applied to the voice mechanism. Our most important discovery was made in this field. We found that the raising of the soft palate shut off the cavities of the upper pharynx and nose and thus diminished by more than one-half the resonance capabilities of the voice mechanism. This action of the soft palate resulted in the loss of more than one-half of the voice itself, as shown by our photographic analysis. This is fully discussed in Chapter VI on "Volume, Quality, and Resonance."

After having trained some singers to produce the voice with the low position of the soft palate, we found that the resulting tone was not altogether satisfactory. This led to a further investigation of the mechanism and the discovery of false cord and tongue interference. This is fully explained in Chapter VII on "Interference."

Finally the discovery was made that all

of these interferences hampered the action of the pitch mechanism, resulting in a loss of two factors, viz., varying the length and the weight of the vocal cords in pitch changes, as described in Chapter V.

In summing up the whole matter of interference, we found that there was not only an appalling loss in volume, quality, and range of pitch of the voice, but that the use of the mechanism under these conditions resulted in a deterioration of the vocal instrument so that effective singing and speaking became impossible. The percentage of voice students who can withstand a long period of training under the present systems and who eventually appear before the public is very small as compared with those who go into the work. Most of these failures are due to the breaking down of the voice mechanism through interference. Those singers whose vocal muscles are strong enough to withstand the abuse of a course of training with interference and who finally make their appearance in public do not last as long as they should. The vocal muscles, if not in-

jured and weakened by interference, will last as long as any other muscle. We should be able to sing and speak effectively as long as we can walk. As one of the most famous singers has put it: "Twenty years ago when I had a voice I had no reputation. Now I have a reputation, but I have no voice."

The next step, which devolved entirely upon the author, was the evolution of a method and the formulation of a series of exercises which, *if properly performed*, will remove these interferences and give full development of the voice mechanism. This is fully outlined in Chapter VIII on "Method."

This method applies with equal force to the speaking and the singing voice, as the correct action of the mechanism in both is precisely similar.

An important factor in the evolution of this method was a consideration of the nature of the two sets of muscles involved, namely, the true tone-producing muscles and the interfering muscles. We found that the action of the tone-producing muscles is involuntary, while that of the interfering mus-

cles is voluntary. This is the fundamental fact underlying the natural method of voice production. It is the great stumbling-block in the path of every teacher and student. Every method now in vogue ignores this, the most important fact underlying the training of the voice mechanism.

At the very outset, the pupil who sings or speaks for the teacher feels that he is doing something out of the ordinary and naturally tries to do the best he can. The fact that he tries involves a use of the will which brings into action the voluntary or interfering muscles. This effort on the part of the pupil is seldom satisfactory to the teacher. The latter then directs the pupil, either by example or otherwise, to sing the tone in some other manner, establishing still further this voluntary action or interference. The case thus becomes hopeless from the start. If the teacher had realized the nature of these two sets of muscles his method of procedure would have been the opposite of this. This is fully explained in Chapter VIII on "Method."

The above shows why imitation of great artists is not desirable. In the first place, any imitation of the voices of great artists is impossible. Any attempts to imitate a tone, to exert a voluntary control over the vocal muscles, means interference. Then many of our great artists have very faulty voice production.

It has been the experience of men in all ages that attempts to accomplish an object by working against nature are not only futile but result in disaster. On the other hand, the successful man first investigates the character of an undertaking and then directs all his efforts in accordance therewith. The more thorough his investigation, the more successful his results.

This rule applies to all lines of business, including that of voice production. If we would be successful in our treatment of the vocal mechanism, we must follow the course pointed out by its nature. It is the business of the anatomist to know the structure of the voice mechanism, of the physiologist to know the function of this structure, and of

the physicist to know the laws of mechanics which regulate the action of this structure in such a manner as to give full use of its function. Herein lies the *nature* of the business of voice production. Only where all of the functions of the vocal structures are brought into use, by the correct application of the laws of mechanics, are we working in accord with the nature of the vocal instrument.

There is an impression which is very prevalent among voice teachers and students that any knowledge of the anatomy and physiology of the voice mechanism is not only useless but detrimental to both. There is a very good reason for this impression, although it is a wrong one. The fault lies largely with the anatomist and the physiologist. The latter has told the voice student and teacher that there is a mechanism. What more natural than that they should try to do something with it. The anatomist and physiologist should have gone a step further and explained fully the *nature* of this mechanism. The teacher and student would then

have appreciated the futility of any attempt *to do anything* with the voice mechanism.

The laws which regulate voice production are precisely the same for every singer and speaker, and every mechanism which produces the voice is exactly similar. Every voice mechanism has vocal cords of exactly the same material—yellow elastic tissue; the action of the cartilages and muscles of the larynx is precisely the same in every speaker and singer, and the conditions which give full use of the resonance space are identical in every normal voice mechanism. Differences in the length and weight of the vocal cords and in the size and shape of the resonance cavities account for differences in the natural quality of voices. For the foregoing reasons there can be one and only one standard method for the teaching of voice production. This must be in accord with the nature of the mechanism and hence may be termed the natural method of voice production.

Every form of interference leaves its blemish on the natural volume and quality of the tone. Hence it is possible to train the

ear to hear in the quality of the tone the interference with the normal action of the mechanism. Tone quality is therefore a test for normal action.

The competent vocal teacher is one, first, who understands the nature of the voice mechanism; second, who can detect in the tone quality of the pupil's voice the interference with the correct action of the mechanism; and third, who can teach him how to eliminate interference and how to develop the vocal muscles. This is fully explained in the chapters on "Interference" and "Method."

In the hands of a competent vocal teacher the student should learn to diagnose and eliminate interference and how to develop his vocal muscles within a year. After he has learned to do this the services of the teacher of voice production are no longer necessary. Full development of the voice, however, would require from three to five years' work on the part of the student, depending upon the extent of injury to his vocal muscles in the beginning.

Finished speech and song involve two things,

correct voice production and interpretation. Without correct voice production our speech and song degenerate into mere mummery and disagreeable sounds. This effect often becomes distressing or ludicrous to the listener on account of evident bodily strain or facial contortion. With correct voice production the matter of interpretation becomes comparatively simple. The latter depends upon the knowledge and experience of the singer, or, in other words, upon his mental capacity. The nature of the voice mechanism itself, and the nature of the art of singing, both demand that once the correct action of the mechanism is established, the singer or speaker should give no thought to the production of his tones. The voice mechanism was made involuntary, so that the whole mind of the performer could be centred upon interpretation. This book deals with voice production and not with interpretation.

The author has frequently been taken to task because he disagrees with all the so-called "authorities" on voice production.

The question arises: Who is an authority on voice production? As we have already stated, the science of voice production is based upon the sciences of anatomy, physiology, and acoustics. It will be found upon examination that the author is in full agreement with the anatomist, physiologist, and physicist, and, therefore, the above statement is untrue. The authors of most books of the present day have not been familiar with the anatomy, physiology, and physics of voice production, and, therefore, are not authorities.

There is nothing mysterious or secret about the teaching of voice production. There is no reason why any one teacher of voice production should possess knowledge which cannot be acquired by every other. Many teachers claim that the successful voice teacher is "born and not made," and that only the select few belong to this class.

There are many such specious claims paraded before the prospective student to catch the unwary. However, the time is rapidly disappearing when the voice student can be deceived by statements which have

no foundation in fact. There are no special dispensations in the art of voice production. There is no knowledge in this field which may not be possessed by any one who will take the time and trouble to acquire it. Physics has replaced metaphysics, and the metaphysician must hie himself to some other field.

The present writer believes implicitly in the honesty and sincerity of purpose of voice teachers. He is convinced, however, that they are unfamiliar with the facts which form the basis of voice production. They do not recognize that there is law and order regulating this process, or there would not be that diversity of opinion which exists among them to-day. Each voice teacher is a law unto himself, and chaos and misdirected effort result. We believe that when he realizes that there is law and order (method) in this as in every other natural process, he will not rest until he has made himself conversant with every phase of it and has learned to direct his efforts in accordance with these natural laws.

Chapter II

INTRODUCTORY

THE scientific method of investigation involves certain very definite and related steps. The first step is definition. The function of definition is to define or limit our field of research. For example, in a consideration of voice production we must limit our investigation to air-waves and the mechanism directly concerned with the production of such air-waves. This limitation must be kept in mind at all times and nothing be allowed to divert the attention from the causes which directly affect the air-waves.

As all things in the universe are directly or remotely related, unless we adhere strictly to our definition, a discussion of voice production would lead us to a consideration of all of the phenomena embraced in our experience. A scientific investigation of voice

production further requires us to establish and relate the causes which directly control the air-waves themselves. While the consideration of secondary and remote causes is often of value in giving a fuller understanding of the direct causes, their discussion without a clear knowledge of direct causes is not only valueless but harmful. Such a treatment of a subject leads to indefiniteness and "muddy speculation"; while a consideration of direct causes leads to definiteness and real knowledge.

At present the literature of voice production consists of a discussion of remote causes. For example, much has been written of the importance of breathing in voice production. The breath is a secondary cause. There are only three direct factors concerned in the production of the air-waves which compose the voice: first, the vibrator (vocal cords), which originates the air-waves; second, the pitch mechanism (cartilages and muscles of the larynx), which determines the rate at which the air-waves are started; and, third, the resonance mechanism (cavities of the

pharynx, mouth, and nose), which amplifies the air-waves after their origination by the vibrator. This amplification is essential to both volume and quality. The breath performs none of these functions and is, therefore, a secondary cause. A discussion of the breath without showing its relation to the action of the vibrator is valueless so far as voice production is concerned.

The same statement holds true in regard to the psychology of voice production. Psychology is defined as the science of the mind. Intervening between the voice mechanism and the mind we find muscles, nerve-fibres, nerve-centres, and their various connections. Until we can show just how the mind can affect one or more of the direct causes, any discussion of psychology in connection with voice production must surely result in a quagmire of indefiniteness and "muddy speculation."

Having defined our field of research, we must now describe in a concise manner those things included in this particular field. Concise description requires analysis.

Analysis thus becomes the second step in the scientific method of investigation. The voice is always a complex tone, *i. e.*, it is made up of several simple tones varying in pitch and intensity. The function of analysis in voice production is to separate the voice into its elements or partial tones. This permits of a description of each partial tone separately and all of them collectively. The first problem which confronted us was the construction of an apparatus which would analyze the voice. It required nearly three years to perfect such an apparatus.

A description of voice analysis led directly to a classification of the facts of voice production. This is the third step in the scientific method.

We found that a complex tone may vary in three ways: first as regards the length of the air-wave, which determines the pitch; second as regards the "height" of the air-waves (degree of condensation and rarefaction of the air particles), which determines the intensity (volume); and, third, as regards the number and relative intensities of the

partial tones, which determine the quality. Anything which may be said about the voice falls under one of these three heads, hence our classification is complete.

Having defined, analyzed, and classified the facts pertaining to the voice itself, we proceeded to investigate in a similar manner the causes which underly these classes of facts. Since these causes exist in the mechanism, we investigated the action of the voice mechanism. This constitutes the fourth step in the scientific method of investigation.

It was discovered through photography of the vocal cords while producing tone that the pitch of the voice is determined by the length, weight, and tension of the cords. Volume of voice is due to the extent of swing of the vocal cords and resonance. Photographic analysis of the voice demonstrated that quality is determined by the vibration of the vocal cords as a whole and in segments and by resonance.

A series of experiments indicated the fact that resonance is the most important factor in both volume and quality of tone. From

our investigations we also found that the conditions in the voice mechanism which give full use of resonance are those which give the most favorable action of the pitch mechanism.

From this it is evident that the proper application of resonance is of prime importance in voice production. The fact that resonance is the most important factor in both volume and quality of tone and that the conditions in the mechanism which give full use of resonance are those which are most favorable to pitch changes demonstrated that these classes of facts are intimately related.

The next or fifth step in the scientific method is to trace out these relationships. It was found that any interference with the action of the pitch mechanism takes away two of the factors in pitch changes, namely, variation in the length and in the weight of the vocal cords. This leaves us nothing but tension to depend upon. Under these circumstances great tension is required for the higher pitches. This extreme tension interferes with

the extent of swing of the vocal cords and therefore with volume, and also with the most favorable segmentation of the vocal cords in the production of the best quality. It was also discovered that the free and unhampered action of the cords originated the most favorable combination of air-waves for the effective application of resonance.

In the course of our experiments we discovered that any interference with the resonance mechanism necessitated a much wider swing of the cords for the production of the required volume. This very wide swing interfered with the proper origination of the partial tones and thus impaired the quality.

A consideration of the classes of facts, their causes, and relationships led us to the conclusion that two things are essential to correct voice production, namely, non-interference with the action of the vocal cords and full application of resonance. These two conditions are absolutely essential to a natural action of the voice mechanism. They constitute the natural law, or the sixth, and last, step in a scientific method of in-

vestigation. A natural law is defined as the description in a few words of a wide range of phenomena. Our natural law conforms in every respect to this definition and is therefore the natural law of voice production.

A natural method of voice production must be based upon this natural law.

The following is a synopsis of the method pursued in the investigation of the action of the voice mechanism.

I. *Definition.*—Voice is air-waves.

II. *Analysis.*—Separation of voice into its elements or partial tones.

III. *Classification of Facts.*—
  1. Pitch = length of air-wave.
  2. Volume = "height" of air-wave.
  3. Quality = number and relative intensities of partial tones.

IV. *Causes of Classes of Facts.*—
  1. Pitch = length, weight, and tension of vocal cords.
  2. Volume =
    (*a*) extent of swing of vocal cords.
    (*b*) resonance.
  3. Quality =
    (*a*) vibration of the vocal cords as a whole and in segments.
    (*b*) resonance.

V. *Relationships of Classes of Facts.*—Length, weight, and tension of the vocal cords must be such as to give

the widest swing for volume and the most favorable segmentation for quality. The combination of air-waves thus started being most favorable for the effective application of resonance.

VI. *Natural Law.*—Non-interference with the action of the vocal cords and the full use of resonance.

Chapter III

DEFINITION

DEFINITION is the foundation for the whole structure of knowledge. Without accurate definition clear thinking and logical conclusions are impossible. It is the very beginning of knowing and the truth cannot be reached without it. It is not only the beginning of knowledge, but is the warp and woof as well. It is the anchor which holds us to the solid ground of reason. For these reasons clear and accurate definition is of the greatest importance in any scientific investigation. Without it we are sure to drift into a maze of idle and barren speculation.

The definition of voice is a very simple matter. We must all admit that the voice is sound. So far as the voice is concerned sound is a sensation produced through the organ of hearing by means of air-waves. The voice

then must be air-waves and can be nothing else.

Pitch is that characteristic of the sensation of sound which depends upon the rate at which the air-waves strike the ear-drum. Air-waves or air-impulses cause the ear-drum to vibrate and these vibrations are conveyed through the auditory mechanism and nerve to the auditory centre in the brain, where the sense-impression of pitch is produced. All air-waves travel at the same rate—approximately 1,100 feet per second. It can be readily understood that a series of long air-waves which produces a low pitch strikes the ear-drum at a slower rate than a series of short air-waves which produces a high pitch. This accounts for our ability to recognize pitch changes.

Volume is that characteristic of the sensation of sound which depends upon the extent of motion of the ear-drum. Air-waves are alternate condensations and rarefactions of the air particles. The greater the degree of condensation and rarefaction the greater the motion of the ear-drum, and consequently

the more intense the impression produced upon the auditory centre.

Quality is that characteristic of the sensation of sound which depends upon the manner of motion of the ear-drum. A single series of air-waves striking the ear-drum will cause a simple to-and-fro motion of it. The resulting sensation we term a simple or pure tone. This simple to-and-fro motion of the ear-drum produces a definite tone quality. When two or more simple tones varying in pitch and intensity strike the ear-drum at the same time there will be set up a complex motion of the ear-drum. The resulting sensation will be quite different from that produced by the simple tone or the simple to-and-fro motion of the drum. By varying the number and the relative intensities of these simple tones many different motions of the ear-drum will occur and consequently a great variety of tone quality will be produced.

Vocal tone is always complex, being composed of several simple tones (fundamental and overtones), varying in pitch and intensity. For the above reasons voice quality depends

upon the number and relative intensities of these partial tones.

The definitions thus far given describe the sensations produced by the action of the air-waves upon the auditory apparatus of the listener or receiver. A consideration of the manner in which these air-waves are produced necessitates a study of the voice mechanism of the producer. Since the air-waves of the voice strike the ear-drum at varying rates of vibration, there must be in the vocal apparatus a mechanism to produce these air-waves at varying rates. This we term the pitch mechanism. This mechanism is composed of the muscles and cartilages of the larynx. The vocal cords (vibrator) are attached to the cartilages of the larynx. The vocal muscles move the cartilages upon each other and thus vary the vibrating length, weight, and tension of the cords for pitch changes. This will be explained more fully in the chapter on "The Pitch Mechanism."

Since the voice is always complex, being composed of several simple tones, each having its own pitch and intensity, then volume of

voice will equal the sum of the intensities of its partial tones (fundamental and overtones). The fundamental tone is originated by the vibration of the cords as a whole and the overtones are started by the vibration of the cords in segments. If the vocal cords are unhampered in their vibration then the swing of the cords as a whole is always greater than the vibration of the segments. When the air-waves thus started are properly reinforced by the use of all the resonance space the intensity of the fundamental tone will be greater than that of any of the others and will provide the major part of the volume. Anything which interferes with the intensity of the fundamental tone is very detrimental to volume of voice.

Since there are good and bad qualities of tone, the manner of motion of the ear-drum to produce good quality must be quite different from that motion which produces disagreeable quality. We find, for example, that a strong high-pitched tone like a shrill whistle produces a disgreeable sensation. A strong high-pitched tone gives a wide and rapid

vibration of the ear-drum. This manner of motion of the ear-drum causes disagreeable quality. On the other hand, a strong low-pitched tone like that produced by an organ-pipe gives an agreeable sensation. A strong low-pitched tone gives a wide and slow vibration of the ear-drum. This motion of the ear-drum is the cause of agreeable quality.

Since it has been shown that a strong low-pitched tone is agreeable and that a strong high-pitched tone is disagreeable, then in a complex tone of good quality the fundamental, which is the lowest pitch, must predominate. In a tone of bad quality the conditions are reversed, and the overtones are stronger than the fundamental.

The question now arises, what action of the mechanism produces the strong fundamental and comparatively weak overtones for good quality, and what action gives the strong overtones and comparatively weak fundamental for poor quality. In the discussion of volume we showed that the unhampered vibration of the vocal cords originated

the strong fundamental, while full use of the resonance space provided the most effective reinforcement. On the other hand, any interference with the vibration of the vocal cords or any cutting off of the resonance space very materially reduces the strength of the fundamental tone.

This proves that in the production of the widest range of pitch, the greatest volume and the best quality of tone there must be non-interference with the action of the vocal cords and full use of the resonance space. This is our natural law.

It has been shown how by the action of the air-waves upon the auditory mechanism an agreeable sensation is produced. It has also been shown just what action of the mechanism produces the combination of air-waves which gives this agreeable sensation. The action of the mechanism has thus been directly connected with the sensation produced. Air-waves furnish the only means of thus connecting the mechanism of the producer with the auditory centres of the listener. The definition of the voice as air-waves is thus shown

to correspond in every detail to the facts concerned in the field of voice production. It is therefore the foundation of all our knowledge of voice production.

Chapter IV

ANALYSIS AND CLASSIFICATION OF FACTS

As the voice is a complex tone a complete description of it requires an analysis of the voice or a separation of it into its partial tones.

The apparatus employed for the analysis of tone is similar to that devised and used by König and Helmholtz, but with some essential modifications. It depends upon resonance; that is, upon the fact that a hollow sphere with a circular opening, about one-fourth to one-sixth the diameter of the hollow sphere, will reinforce one pitch, and one only. Its air can normally vibrate at that rate, and at no other. The pitch of the tone which such a "resonator" will pick out depends upon the diameter of the sphere and that of the opening. Fig. 1 shows a section of such a resonator, as made by König. *B* is the opening with a slight lip, with which it is

tuned. *C* is a slight conical extension at the back, opposite to *B*. If this extension is put into the ear it will be found that all sounds are heard faintly, except those of the pitch to which the resonator is tuned, and this is greatly reinforced. With sets of such resonators one is in a position to determine, by listening, whether a given tone is present in any complex sound. This method is very accurate and delicate, but very inconvenient. König devised a better way of observing what the resonators are doing. We have, however, decidedly modified König's apparatus. The resonators, *A* (Fig. 1), are so mounted in a plank, *P*, that the point, *C*, is flush with the back. A block, *H*, screwed upon the back of *P* has a conical hole conaxial with the resonators, into which fits the conical plug, *G*. The inner end of *G* is hollowed out to leave a small cavity, *D*, over which a thin membrane of rubber is stretched. The latter is bound around the end of *G*. Gas enters the cavity, *D*, by the tube, *E*, escaping by the central tube, and burning in the small flame at *F*. When the tone of this resonator is sounded, the air in *A*

responds (that is, it vibrates), making the drumhead at *D* vibrate, thus causing the little flame at *F* to jump at the same rate as the vibration of the tone. Looking simply at the flame we see little change, since its jumps are so rapid, 128 to 1,024 per second, that the eye fails to distinguish them. If, however, we observe the flame in a moving mirror each jump will appear in a different place, and hence be visible. A stationary flame viewed in such a rotating mirror appears as a line of light; a jumping flame appears like the teeth of a saw, the distance between the teeth depending upon the relation of the rapidity of motion of the flame to that of the mirror. Similarly, if the image of such a flame fall upon a moving photographic plate, the trace developed will be a true report as to the state of rest or agitation of the flame. Such are the principles and devices underlying the apparatus shown in Figs. 2 and 3. Fig. 2 is the front view, showing the eight resonators of various sizes, the rotating mirror, a few of the small flames, and the camera at the back. In Fig. 3 are seen the "manometric capsules" with their connecting tubes and little flames. A spherical

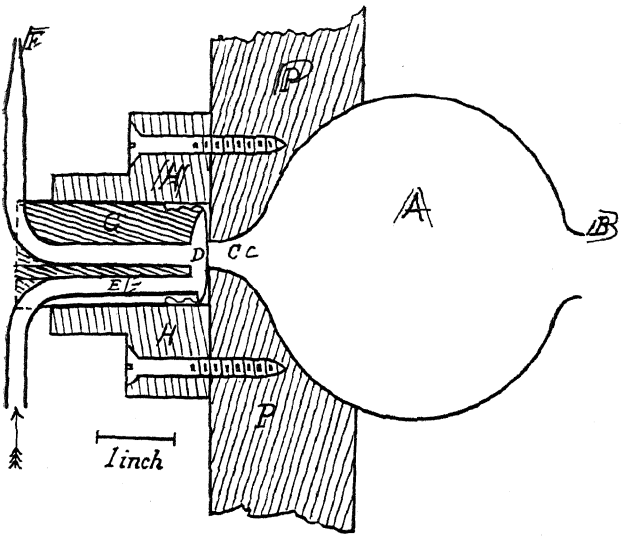


FIG. 1. Section of resonator and its manometric capsule.

A. Resonator. *B*. Mouth of resonator where air-waves enter. *C*. Small extension through which the air-waves strike upon the rubber drum between *D* and *C*. *D*. Space behind the drum to which the gas enters through the tube *E*, and from which the gas passes out and burns at *F*. *G*. Wooden plug carrying gas tubes and hollowed out to form the space *D*. The rubber is stretched and tied over the end of *C*. *H*. Block to hold *G*. *P*. Plank on which the whole is mounted.

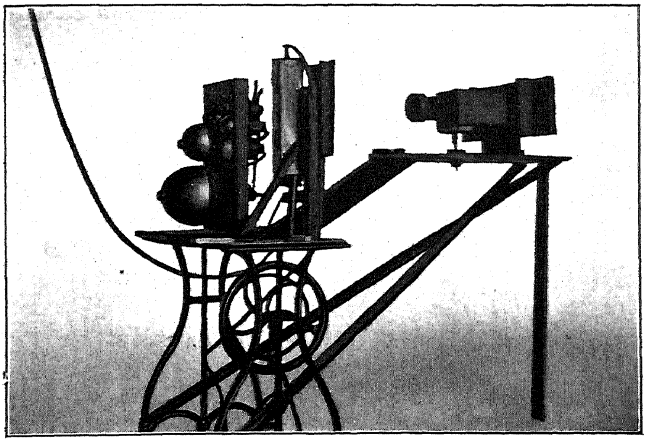


FIG. 2. General view of the apparatus showing the resonators, the rotating mirror, and the camera at the back.

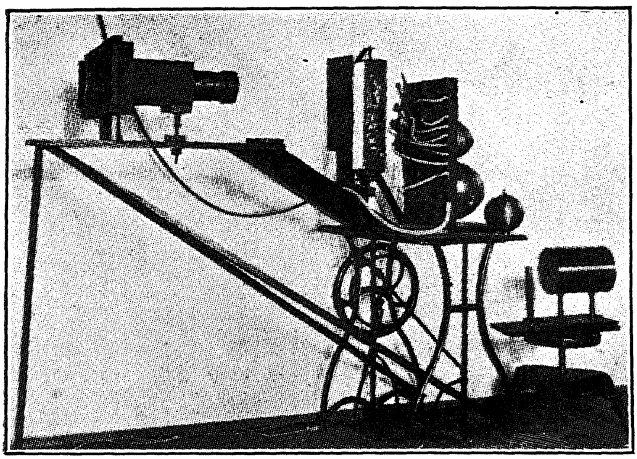


FIG. 3. General view showing the capsules and their attachments, the flames reflected in the mirror, and the sliding plate-holder at the back of the camera.

A spherical resonator stands on the corner of the table and our standard tuning-fork with its cylindrical resonator is on the low stool.

resonator stands upon its mouth on the corner of the table, and our standard fork with its cylindrical resonator stands upon the stool. A device at the back of the camera enables us to move the photographic plate across an opening through which fall the images of the flames. This gives a record of the report of each flame and its resonator, upon any tone produced in front of them. Fig. 4 is such a record when a certain voice was singing *ä* (as in father), upon the pitch of our standard fork, which is 128 vibrations per second, or about "bass C." The number of vibrations that the fundamental or characteristic tone or pitch of a string bears to the rate of its overtones, harmonics, or upper partials, is the ratio of 1 to 2, 3, 4, 5, 6, etc. Hence our resonators are tuned to bass C, and its first seven overtones, whose rates of vibrations and approximate pitches are given below.

Fundamental,	128	vibrations	per	second,	about	C_1
1st overtone	256	"	"	"	"	C_2
2d "	384	"	"	"	"	G_2
3d "	512	"	"	"	"	C_3
4th "	640	"	"	"	"	E_3
5th "	768	"	"	"	"	G_3
6th "	896	"	"	"	"	$B\flat_3$
7th "	1,024	"	"	"	"	C_4

The number of points in the lines in Fig. 4 are proportional to the above numbers; that is, to 1, 2, 3, 4, etc. The above series of overtones of a string were adopted because they are the overtones in the voice, and, moreover, as will be made evident in a later chapter, because the vocal apparatus is a stringed instrument, both in theory and practise. Thus an instrument has been obtained which can analyze the voice.

In the present chapter we discuss the behavior of vibrating strings, reeds, etc., and apply the conclusions directly to the explanation of the mechanism of voice production.

If we examine a string attached at each end and vibrating, we shall find that three factors control the rate of vibration—in other words, the pitch of the tone emitted. These factors are the length, weight, and tension of the string. The rate of vibration of a string is inversely proportional to the length of the string—*i. e.*, a string of half the length of another will vibrate twice as fast, and hence will give the octave. The rate

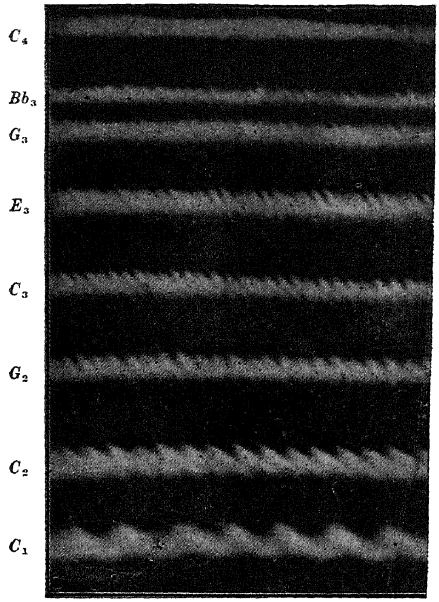


FIG. 4. Photograph of the motion of the flames while singing the vowel *ä* as in father.

The lower line is the fundamental, and the others are the 1st, 2d, 3d, etc., overtones in the order of their pitch. One wave of the fundamental corresponds to two in the first overtone, three in the second, four in the third, and so on.

is proportional to the square root of the stretching force. If we wish to raise the pitch of a string to the octave by increased tension, we must put upon it not twice, but four times, the stretching force. The rate of vibration is inversely proportional to the weight of the string. A string of half the weight would give the octave, other things being equal. It will be shown later that the larynx contains the means for varying these three factors. The quality of the tone produced by a string depends upon the number and relative strength of the partial tones. The mathematical theory, as well as the experimental results, show that these overtones form a series whose rates of vibration together with that of the fundamental or pitch tone, are proportional to the natural numbers 1, 2, 3, etc. For every vibration of the fundamental there are two in the first overtone, three in the second, and so on. Note well that these are in harmony with the fundamental and each other, at least to No. 6, then also 8, 10, and 12.

There are several very satisfactory ways

of showing how a string divides up into segments when vibrating to its various overtones. Fig. 5 gives a series of photographs of a vibrating string taken by means of an apparatus devised by Professor W. L. Robb, of Trinity College, Hartford, Connecticut. Photograph marked *A* shows the string swinging as a whole as it does when giving its fundamental or pitch tone. This fundamental tone is shown as *C*, in Fig. 4. This is its slowest rate, and consequently produces its lowest-pitched tone. It will be seen that the string moves as a whole from one side to the other in a very simple motion. A string vibrating in this way would give a pure or simple tone. A "pure tone" is one which is produced by one single rate of vibration, as a tuning-fork with its resonator. This is the definition universally adopted in the science of acoustics. It might be well for writers upon music to conform to this usage and not call a tone by Melba "pure" when they mean fine or pleasing, and when the fundamental has at least three or four overtones with it. *B* shows the same string as *A*, only now vibrating to the

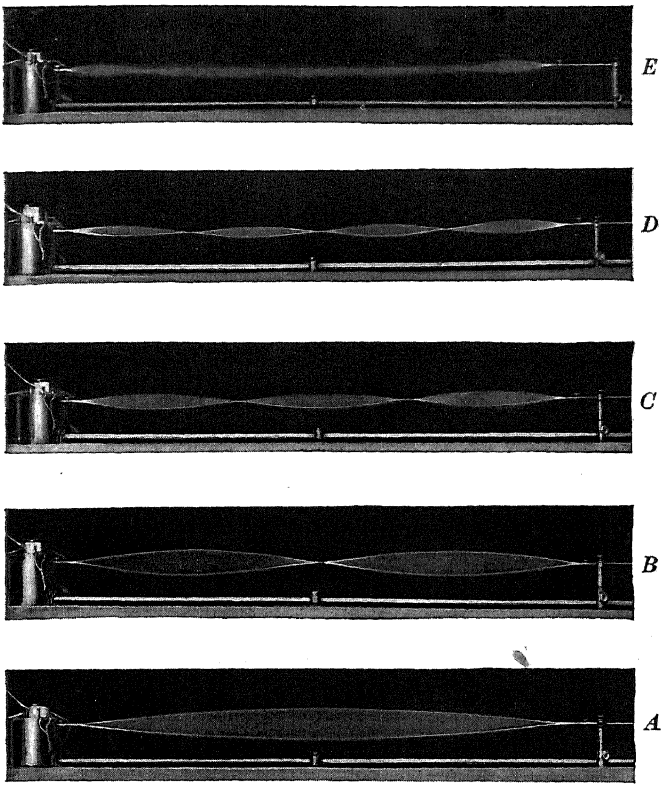


FIG. 5. Vibrating string showing its vibrations as a whole and in segments.

first overtone. This is the octave and has twice as many vibrations as in the fundamental. There is a "node," or point of rest, in the centre, and two segments. One readily sees that the effective length in *B* is one-half that in *A*. *B* corresponds to C_2 in Fig. 4. In *C* we have the second overtone, the fifth above the octave, with two nodes and three segments, and with one-third the effective length of *A*. *C* corresponds to G_2 in Fig. 4. *D* is the third overtone, the double octave, with three nodes and four segments. *D* corresponds to C_3 in Fig. 4. *E* is a photograph of the same string vibrating so as to give several overtones at once. It is not known at present which overtones are active in *E*.

If now we turn our attention to the case of a vibrating reed or rod, fastened at one end and free at the other, we find its pitch controlled by its length, thickness, and elasticity. The ratios of the rate of vibration of the fundamental to its overtones are about as 1 to $6\frac{1}{4}$ to 7, and to the squares of the odd numbers, 3^2, 5^2, etc. The first overtone of a reed sounding 128 v. p. s. as its pitch or

fundamental tone would be approximately 800 v. p. s. Its position is marked by an arrow in Fig. 4. Note well in this connection that there are five overtones in a string before we come to the first overtone of the reed; also that none of the overtones of the reed are in simple harmony with either the fundamental or with each other; also that their pitch varies with the varying form of the reed. This proves that the voice is not a reed tone, but a string tone. For this reason the vocal cords must segment like the string and not like the reed.

In the case of disks and membranes there are no harmonious overtones. In fact, Helmholtz classes reeds (rods), disks, and membranes as sources of sound "with inharmonic overtones."

Musical instruments and voices differ from each other in quality. That is to say, in the relation of the number, pitch, and intensity of the overtones to the fundamental.

A study of the voice analysis, Fig. 4, shows us that there are three things to describe in this photograph: The first is that the air-

waves vary in length for the different tones. This length is measured in the photograph by the distance from the apex of one serration to the apex of the adjacent serration. The fundamental tone which is seen to have the longest air-wave has the lowest pitch. The air-wave in the first overtone is but half the length of that in the fundamental, and gives us the octave in pitch. The air-wave in the second overtone is one-third the length of the air-wave of the fundamental, and this gives the twelfth of the fundamental or the fifth of the first overtone. We find that as the air-wave length decreases the pitch rises. Therefore the air-wave length determines the pitch. Pitch is our first class of facts.

The second thing which we notice in this voice photograph is that the air-waves vary in "height." This "height" is measured in the photograph by the perpendicular distance from the hollow to the crest of the wave. Our experiments demonstrated that the fundamental tone, or the one with the "highest" wave, could be heard the greatest distance, and that the intensity and carrying power

of the overtones diminished in the same proportion as the "heights" of their air-waves. We can conclude therefore that intensity and carrying power (volume) depends on the "height" of the air-wave. Volume is our second class of facts.

In the third place we noticed in our work of voice analysis that as the number or relative intensities of the partial tones varied, the quality also changed. This fact demonstrated that tone quality depends absolutely upon the number and relative intensities of these partial tones. Quality thus becomes our third class of facts.

A critical examination of this voice photograph shows that there is nothing further to describe. Every fact which has any bearing upon the voice may be placed under one of these three classes, hence our classification is complete. We are now in a position to understand how a description of voice analysis results directly in a classification of the facts of voice production.

Chapter V

PITCH

PITCH of the voice is controlled entirely in the larynx and is determined by the length, weight, and tension of the vocal cords. The vocal cords are two in number and are attached to the cartilages of the larynx. These cartilages and the vocal muscles compose the pitch mechanism. The motion of the cartilages produced by the action of the vocal muscles varies the length, weight, and tension of the vocal cords for pitch changes.

There are four cartilages concerned in pitch changes, the thyroid or largest cartilage of the larynx, which forms what is ordinarily termed the "Adam's apple"; the cricoid cartilage, which is hinged on each side to the thyroid by means of two projecting arms extending down from the thyroid on each side of the cricoid and partially enclosing it;

and the two arytenoid cartilages which are mounted upon the upper and back part of the cricoid.

The vocal cords extend horizontally across the larynx from front to back. They are attached in front to the inner portion of the thyroid and posteriorly to the arytenoid cartilages. The attachments of the vocal cords to the thyroid are near each other, so that when the arytenoids are approximated the cords are parallel.

When not producing tone, the arytenoids and the vocal cords are widely separated to allow a free passage for the breath. The arytenoid cartilages are so attached to the cricoid that they are capable of three distinct motions. First, they are brought together by the action of the arytenoid and the lateral cricoarytenoid muscles. This motion of the arytenoid cartilages not only approximates the vocal cords, but also gives them sufficient tension to produce tone. This position of the cords and arytenoids produces the lowest pitch of which the mechanism is capable. After the arytenoid cartilages have been

brought together in the manner indicated above, they are rotated by the action of the thyro-arytenoid or "vocal" muscles.

This rotation of the arytenoids has the effect of pressing the cords together at their posterior ends, thus shortening their vibrating length for the production of the higher pitches. Photographs of the vocal cords while producing tone shown in Fig. 6, demonstrate that the vibrating portion of the cords may be shortened at least one-half by this action of the "vocal muscles."

The third motion of the arytenoid cartilages is produced by the action of the posterior crico-arytenoid muscles. The contraction of these muscles separates the arytenoid cartilages and the vocal cords and brings them to the position occupied by them during breathing.

The "vocal muscle" (*thyro-arytenoideus*) lies directly outside the vocal cord and parallel with it. It is attached in front to the thyroid cartilage just exterior to the attachment of the vocal cord and posteriorly to the outer angle and to a portion of the outer edge

of the arytenoid cartilage. The posterior end of the vocal cord is attached to the front angle and to a portion of the interior edge of the arytenoid cartilage.

Fig. 6 shows four photographs of the vocal cords, looking down upon them. The front attachment is out of sight at the bottom of the pictures, being covered by the epiglottis, *i*; *l* is the cords themselves, with the apparent slit, *k*, between them; at the back, *bb*, are the arytenoid cartilages. The "vocal muscle" is attached to the outside of the arytenoid cartilage at a point near *n*. It extends forward through the thick part of the cord and is attached near the cord to the front of the thyroid. When these muscles are contracted they cause the arytenoids to rotate around a point near *bb*, throwing the forward ends, *o*, inward toward each other. This rotation of the arytenoids results in a shortening of the effective length of the cords and a consequent raising of the pitch. In I and II the person is singing low *G*, and the whole length of the cord is in vibration. III shows the position when the octave of low

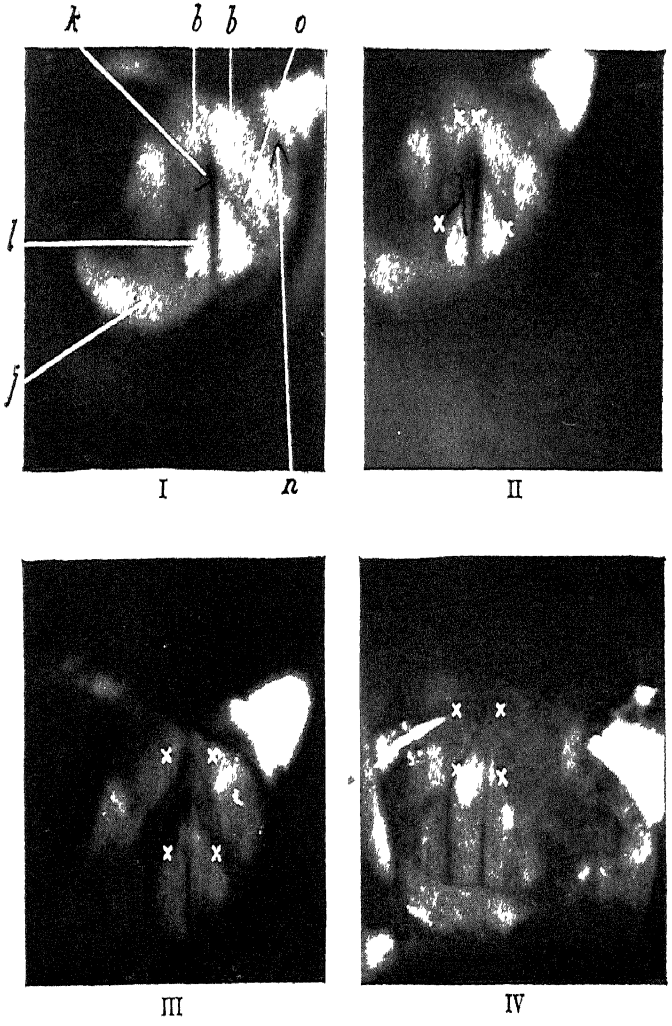


FIG. 6. The vocal cords while producing tones of various pitches.

G is sung, and IV when the two octaves above low *G* is the pitch. A comparison of II, III, and IV, especially as to the position of the crosses marking the front and rear angles of the arytenoids, will show how the cartilages are rotated and the cords shortened as the pitch rises.

Imaginary lines connecting the front and rear crosses on each side mark the inner edges of the arytenoid cartilages. In II this line makes a decided angle with the vocal cord. In III this line is nearly parallel with the cords, and in IV the line is parallel with the cords. The position of these lines in the photographs should make the relative position of the cords and cartilages very clear. This change in the position of the arytenoid cartilages has the effect of pressing the cords together at the back, thus shortening their vibrating length.

For the low *G*, as shown in II, the cord is vibrating in its full length. For the middle *G* a very considerable shortening of the vibrating length of the cord is shown. In IV, where the high *G* is being produced, the cord

a much lighter string and thus helping to get a high pitch with a minimum of tension.

When we consider that the rotation of the arytenoid cartilage throws its outer angle, near *n* (Fig. 6), to which the "vocal muscle" is attached outward and the front angle, *o* (Fig. 6), to which the vocal cord is attached inward we can understand how this rotation tends to separate the cord from the muscle. This separation of the vocal cord and the "vocal muscle" places the little muscular fibres, shown in Fig. 7, in a position so that when they contract they will damp those portions of the cord to which they are attached. This action of the muscular fibres of the "vocal muscle" which are attached to the vocal cord will lessen the vibrating weight of the cord at least one-half.

If we lessen the vibrating weight of the cords one-half we raise the pitch an octave.

There is a movement of the cricoid cartilage upon the thyroid produced by the action of the crico-thyroid muscles which varies the tension of the cords for pitch changes. This

will be understood more clearly by reference to Fig. 8. This shows three views of the larynx: I, a vertical section from front to back; II, the left side of the cartilages; III, the left side with some of the muscles. *e* is the large thyroid cartilage, the front point of which forms the "Adam's apple," just behind which is the front attachment of the vocal cords. This cartilage is hinged upon the cricoid, *a*, by two projecting horns, *d*. Upon the back top part of the cricoid sit the two arytenoid cartilages, *b*, which form the rear attachments of the vocal cords. The thyroid is held in place by muscles running up to the soft palate and head, and down to the collar-bone. When the muscles, *h*, are contracted, the front edge of the cricoid is drawn up, closing the niche, *c*, and tilting on the hinge, *d*. The back top of the cricoid, with the arytenoids, *b*, is thereby carried backward, lengthening the cords slightly and increasing their tension.

The white line shown in I indicates the position of the vocal cords. The relative position of the cricoid and thyroid cartilages

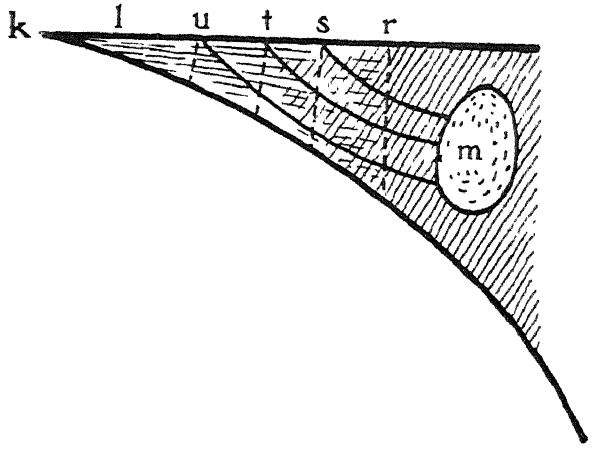


FIG. 7. Schematic representation of the vocal cord and muscle.

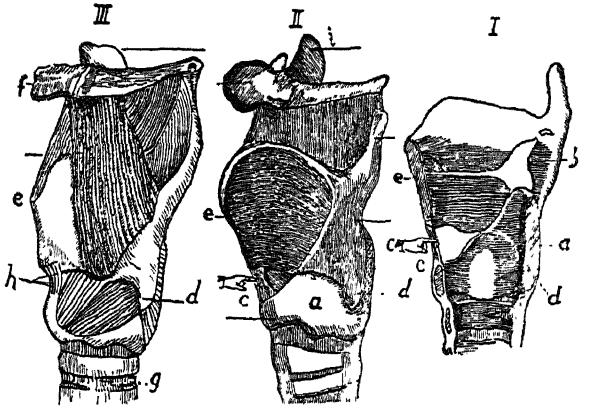


FIG. 8. Three views of the larynx.

in this view is that of rest. It shows quite a distance between the upper and front part of the cricoid and the lower and front part of the thyroid where the hand is pointing. This space is filled in by thin membrane so that it is possible to pull the upper edge of the cricoid against the lower edge of the thyroid, thus closing the little niche. This motion is effected by the contraction of the crico-thyroid muscles shown at *h*, III. The permanent attachment of the cricoid to the thyroid is at *d*. If we pull the front part of the cricoid up while the portion *d* remains stationary, it will have the effect of throwing the upper and rear part of the cricoid to which the arytenoid cartilages are attached backward and downward. As the arytenoids are carried along with the cricoid, the distance between the front and rear attachments of the vocal cords will be increased, thus increasing the tension of the cords. This tilting of the cricoid upon the thyroid with its consequent effect of very considerably increasing the tension of the cords should alone give us a rise of an octave in pitch.

We must bear in mind that these three actions, namely, the lessening of the length, the lessening of the weight, and the increasing of the tension are being carried on simultaneously. They are produced by the contractions of the "vocal" and the crico-thyroid muscles acting at the same time. For the lower pitches there is only a slight contraction of these muscles. For the higher pitches there is a very considerable contraction. It is the degree of contraction of these two muscles acting together which produces all the pitch changes of the voice. There is no change in the action of the mechanism and therefore no "registers."

It will be seen that we have in the larynx the means for controlling the three factors which determine the pitch of a string—length, weight, and tension. Moreover, the tuning mechanism of a reed, plate, or membrane is lacking. Actual analysis shows the overtones of the vocal cords to belong to the series of a string, and not to that of a reed, plate, or membrane. We are thus forced to the conclusion that, both in its action and

in its resulting tone, the voice mechanism is a string instrument.

This analysis of the pitch mechanism demonstrates that if not interfered with it is capable of producing a range of three octaves in pitch.

Chapter VI

VOLUME, QUALITY, AND RESONANCE

AS resonance is the important factor in both volume and quality, it has been thought best to consider all three in one chapter.

Volume of voice has been defined as the sum of the intensities of the partial tones. This depends upon the extent of swing of the vocal cords and resonance.

Resonance is the keystone of our work. It is at once our tool and the object for which we labor. For our purpose resonance may be defined as the reinforcement of a tone by a quantity of more or less confined air, the inherent rate of vibration of which is identical with that of the tone reinforced. Such a quantity of air receiving successive impulses from the vibrating object comes into vibration itself, thus giving to the surrounding air a much greater amplitude of vibration and

consequently greater intensity and carrying power to the tone. The jew's-harp is an excellent illustration. In it the mouth cavity reinforces the tones of the little tongue. In fact, the size of the cavity in this case, selecting its own pitch from the complexity of sounds produced by the harp, and so reinforcing it, makes it the characteristic tone, which varies in pitch with the size and shape of the mouth cavity. To a lesser extent do the cavities of the mouth and nose act selectively upon the tones produced by the vocal cords, thus modifying the quality of the tone, as in the production of the different vowel sounds, but never determining the characteristic pitch (fundamental), which is entirely controlled in the larynx.

Fig. 9 is a section through the head and neck, showing the location of the parts essential to our study. Many of the parts will be readily recognized. One is at once struck with the great size of the cavity of the nose and upper pharynx, even as compared with that of the mouth. The soft palate (12) acts as a door between these two resonators.

When it is drawn back and closed (as in Fig. 10), it cuts off the upper cavity entirely, leaving only the mouth and lower pharynx available for resonance purposes. It is impossible for air-waves in the mouth and lower pharynx to set the air in the nose and upper pharynx in motion through either the bony roof of the mouth or the flesh of the soft palate. The vocal cords are attached in front to the middle of the thyroid cartilage (Fig. 9, No. 6) and, at the back, to the arytenoid cartilages (No. 14), which sit upon the rear upper part of the cricoid cartilage (No. 17). No. 17 sits directly upon the top of the windpipe. The sound-waves from the cords pass out, under and behind the epiglottis (No. 13); thence past the soft palate (No. 12), either into the nasal cavity and out the nostrils or over the tongue, under the hard palate (No. 11) and roof of the mouth, and out between the teeth and lips. Nos. 2, 3, 4 are the turbinated bones which bulge out into the nose cavity, breaking it up into narrow passages, which is also done by the septum, or partition, which divides the nasal cavity into

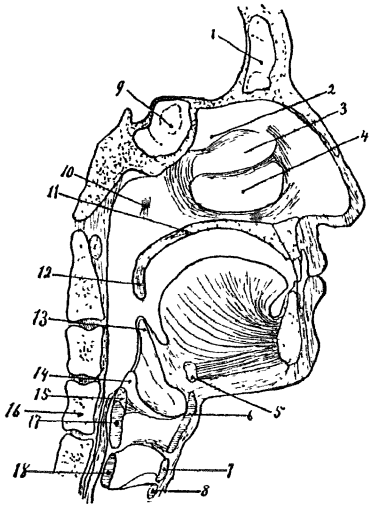


FIG. 9. Vertical section of the head to show location and relative size of the resonance cavities.

1. Frontal sinus. 2, 3, and 4 Turbinated bones. 5. Hyoid bone. 6. Thyroid cartilage. 17. Cricoid cartilage. 7 and 18. Top ring of the trachea. 9. Sphenoidal sinus. 10. Entrance to the eustachian tube. 11. Hard palate. 12. Soft palate. 13. Epiglottis. 14. Arytenoid cartilage. 15. Arytenoideus muscle. 16. Vertebra.

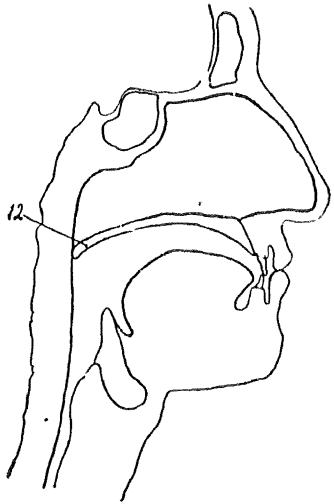


FIG. 10. Vertical section of the head, similar to FIG. 9, but showing how raising the soft palate (12) and closing the passage diminish the space available for resonant re-enforcement by cutting off the large cavity of the upper pharynx and nose.

a right and left half. This irregularity and complexity of the spaces and passages enable the resonance cavities to lend resonant reinforcement to a much greater range of pitch than if they were regular and simple. This is a fact of fundamental importance in the discussion of volume and quality. No. 10 is the entrance to the Eustachian tube, leading to the inner ear. No. 9 is the sphenoidal sinus, and No. 1 is the frontal sinus. It is sometimes urged that these cavities, together with the antra, which are located in the cheek-bones, aid in resonance, but this is practically impossible, since at best their openings are small, and they are usually closed entirely, as is the cavity of the inner ear. A closed cavity cannot reinforce a tone. This statement applies also to the cavities below the vocal cords; that is, the "chest cavities." Vibrations of the air in them may take place, and possibly may exert some influence on the cords, but they cannot aid in the resonant reinforcement of the tone. The intensity, or carrying power, of a tone depends upon the "height" of the air-waves, and may be ob-

tained by increased activity of the source of sound (of the cords) or by resonant reinforcement. The former method strains the vocal muscles and exhausts the breath; the latter requires no effort, only the correct use of our resonance cavities, as will be shown later.

It will be seen that the cavities available for resonant modification and reinforcement of tone are those of the upper and lower pharynx, the mouth, and the nose. The muscles which control the size, arrangement, and openings of these are the muscles of the soft palate, tongue, jaw, and lips. It is quite easy to determine whether the nose cavity is in use and the soft-palate door down. While singing the tone, gently close the mouth. If the soft palate is up the tone will stop; if it is down the tone will continue through the nose. Again, while singing, gently close the nose with thumb and finger; it will not affect the quality or volume of the tone if the soft palate is cutting off the nasal resonance, but will give a decided change in quality and great loss of volume if the soft palate is down. The quality of the voice is not controlled as

it is in any other instrument; in fact, it would be almost impossible to so control it mechanically at the cords. It has been pointed out that a volume of air more or less enclosed can act to reinforce a tone of its own particular pitch. Now we have, in the lower and upper pharynx, mouth, and nose, resonance cavities, the size and openings of which are sufficiently under our control to enable us to reinforce certain tones or pitches at the expense of others. In vowel production we vary these cavities so that their resonant effect changes the quality from that of one vowel to another. It must, however, be borne in mind that these overtones, whose variation enables us to enunciate the vowels and to express the various emotions, are originated *in the cords themselves*, and that they are modified only as to their relative intensities by the resonance cavities above. Any other origin of the overtones is absolutely incompatible, as well with theory as with observed facts. Another fact that must be accepted is that the only resonance available, either for reinforcement or modification, is the resonance of the *air* in

the above cavities. Any vibrations that may occur in the air in the chest are useless for reinforcement, since the cavity is closed, and a closed cavity cannot reinforce a tone. Resonance from the spine, jaw, or muscle is simply ridiculous. These are often referred to as "valuable sounding-boards." Bone is 48.6 per cent water, and the other structures are from 75 per cent to 90 per cent water. Imagine the tones of a piano with water-logged sounding-board! Let any one take an ordinary tuning-fork, and, striking it, press the shank upon a board, and hear the tone sound. Then striking it again, try to get a similar reinforcement by pressing the shank upon his friend's skull, spine, cheek, or neck.

The immense importance of resonance in the production of volume may be appreciated by the use of a tuning-fork and resonator tuned to its pitch. If we listen to the sound produced by the tuning-fork alone its fundamental tone can be heard only a few inches from the ear. If we strike the fork with the same force as before and then hold it close to the mouth of its resonator its fundamental

tone may be heard at a distance of at least two hundred feet. We have thereby increased the intensity and carrying power of the tone several hundredfold.

We are in a position now to appreciate the effect upon volume of voice produced by the raising of the soft palate. This act cuts off more than one-half of our resonance space and produces a corresponding diminution in volume of the tone. To compensate for this loss we must increase the swing of the cords, the only other factor in the production of volume. This means the expenditure of much more breath, the overworking of the vocal muscles, and an impairment of tone quality. The breath vibrates the cords. For a wide swing of the cords much more breath is used than for a slight swing. With full use of resonance a comparatively slight swing of the cords will give us almost any volume desired. The full use of resonance is therefore the most important factor in economizing the breath. A wide swing of the cords also puts a strain upon their attachments and so gives more work for the vocal muscles to do. Continued over-

work impairs the efficiency of the vocal muscles, and causes deterioration of the voice mechanism.

Full use of resonance then is an important factor in the preservation of the voice.

It is easily demonstrated by any stringed instrument that a very wide swing or, as it is termed, "forcing the string," impairs the quality. For example, a moderate blow of the hammer upon the string produces a much better quality of tone than a very strong blow. This is accounted for by the fact that in a very wide swing of the string the increase of the vibration of the segments of the string is much more pronounced than the increase of the swing of the string as a whole. The result is that the higher overtones are too strong for the fundamental and harshness is produced. This explains what a critic means when he says that a pianist "forced his instrument."

Quality of voice depends upon the vibration of the cords as a whole and in segments, and upon resonance.

We have shown in Figs. 4 and 5 and the

accompanying description just how these partial tones are originated by the cords.

If the swing of the cords is not interfered with the proper combination of partial tones for good quality will be originated by them. In other words, if there is a free swing of the cords, the fundamental tone is strongest and the overtones diminish in intensity as they rise in pitch. After these various partial tones leave the vocal cords and as they pass through the resonance cavities their intensities are greatly modified by the action of the air in these cavities. This modification depends entirely upon the size and shape of the cavities. We have already pointed out that a tone of good quality must have its fundamental or lowest pitch in the tone the strongest. It is a well-known fact of physics that to reinforce a low pitch a large cavity is necessary. If we cut off the upper pharynx and nasal cavities by raising the soft palate there is not sufficient resonance space left to properly reinforce the fundamental tone and it remains weak. Furthermore, the raising of the soft palate cuts off the small cavities of the nose

which are essential to the reinforcement of the highest partial tones and they are practically "damped out."

The strong fundamental tone gives the bigness and fulness to the voice while the high overtones give a certain richness to the quality which can be obtained in no other way. Moreover the presence of the high overtones enables the singer more readily to modulate the voice for the expression of the different emotions. The most desirable quality and the greatest volume as well as the preservation of the voice mechanism have been shown to depend upon the *free action of the vocal cords and full use of the resonance space.* A discussion of volume, quality, and resonance has led us inevitably to a restatement of our natural law.

Chapter VII

INTERFERENCE WITH THE ACTION OF THE MECHANISM

THE correct action of the voice mechanism consists in the unhampered vibration of the vocal cords, the free motion of the cartilages and muscles of the larynx, and full use of the resonance space. This action gives the natural voice or the voice which nature intended a particular mechanism to produce. Any muscular contraction which prevents the unhampered vibration of the vocal cords, the free motion of the cartilages and muscles of the larynx, or full use of the resonance space is termed an interference.

The voice mechanism proper is located at the upper end of the respiratory tract, and a part of it is identical with the upper end of the alimentary canal, or that part of it especially employed in the act of swallowing. The mouth

and lower pharynx form an important part of the resonance mechanism of the voice as well as the beginning of the digestive tube. When we swallow, the muscles concerned in this act pull the larynx (pitch mechanism) upward and forward, out of the way of the path of the food. The muscles of the soft palate contract, raising the soft palate against the back of the pharynx and thereby closing the opening into the upper pharynx and nasal cavities. The false cords are also drawn together, closing the opening into the larynx, and the epiglottis is pulled down over the larynx, thus making this closure more secure. For this reason, when we swallow we cannot produce tone, and the two acts are necessarily antagonistic.

If full use of the swallowing muscles prohibits voice production we may infer that even a slight contraction interferes more or less, as the case may be. We find this to be true. Our next step is to discover how this interference is produced. Like swallowing, voice production depends on muscular action. We have, then, in the throat two sets

of muscles whose action is antagonistic. When one set is active the other must be quiescent or trouble ensues. For example, when tone is being produced the swallowing muscles (those of the false vocal cords, pharynx, soft palate, and back of the tongue) must be absolutely relaxed in order to get the full use of all the capabilities of the vocal instrument.

As the larynx is pulled upward and forward during the act of swallowing, it is evident that one end of these swallowing muscles is attached directly or indirectly to it, while the other end is attached to some portion of the head or neck. For these reasons the swallowing muscles are termed the extrinsic muscles, and the vocal muscles the intrinsic muscles of the larynx. The vocal muscles are attached wholly to the cartilages of the larynx.

The principal forms of interference are, first, the contraction of the muscular fibers of the false vocal cords which prevents the free vibration of the true vocal cords; second, the contraction of the muscles of the soft

palate which prevents the use of at least one-half the resonance space; and, third, the contraction of the muscles of the chin and of the back of the tongue which prevents the correct action of the pitch mechanism.

False-cord interference can be understood by reference to Fig. 11. This is a vertical section of the left side of the larynx, showing the true vocal cord, the vocal muscle, the ventricle of the larynx, and the false vocal cord. It should be borne in mind that there is another side of the larynx identical with this and opposite to it. *e* shows the yellow elastic tissue forming the true vocal cord. This section was taken from a cadaver and all the tissues were completely relaxed. During voice production the true vocal cord is drawn up more in the position indicated by the dotted line *fga*. *m* shows the bundles of muscular fibres forming the "vocal muscle" which is seen to lie just outside the true cord. *d* is the ventricle of the larynx. The black dots indicated by *l* represent bundles of muscle fibre which entirely surround the ventricle. *b* points to the structure of the

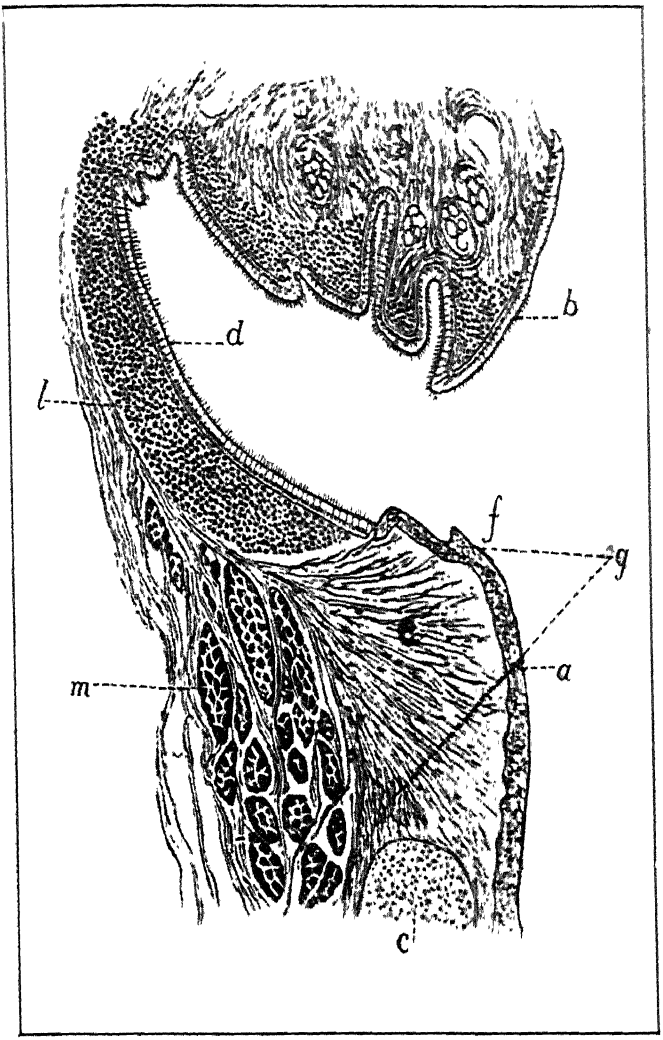


FIG. 11. Cross-section of one side of the larynx.

false vocal cord. The function of the ventricle of the larynx is, first, to provide a free space for the true cord to vibrate in. Secondly, the mucous membrane lining the ventricle is filled with glands which secrete mucus for the purpose of keeping the vocal cords moist. This mucous coating of the vocal cords is essential to their perfect vibration.

During voice production there must be a complete closure of the glottis each time the cords swing past their point of rest, otherwise the tone would be "breathy," as there would be a constant escape of the breath between the cords. This closure cannot be effected by an actual touching of the cords themselves, as this would interfere with their vibration and the tone would stop. The coating of mucus upon the cords enables them to make this closure without the actual touching of the cords.

During the act of swallowing, the muscular fibres surrounding the ventricle of the larynx and composing the false vocal cords contract, pulling in the soft tissues surrounding the ventricle upon the true cords and approxi-

mating the false vocal cords. This action practically obliterates the ventricle for the time being and squeezes out the mucus from the glands in it on top of the true vocal cords, thus furnishing them with the mucous coating necessary for their perfect vibration. This is the only function of the muscular fibres of the ventricle and of the false cords in voice production. This action should only occur in the intervals between tone production. Unfortunately most singers and speakers maintain more or less contraction of these muscular fibres during voice production, thus pulling in the false cords and the soft parts surrounding the ventricle, thereby interfering with the free swing of the true cords. This interference affects principally the swing of the true vocal cords as a whole, diminishing very greatly the strength of the fundamental tone. Strong false-cord interference will almost completely obliterate the fundamental tone. Such an effect is heard particularly in the typical "concert-hall" singer. The late Professor Hallock used to say: "The concert-hall singer sings in overtones." As

the strong fundamental tone is so important in the production of volume and quality, it may be readily understood that false-cord interference is very detrimental to both. The pulling in of these soft parts makes the cords heavier. False-cord interference is a fruitful source of faulty intonation. The so-called "nasal" quality is due entirely to this cause. *In fact any roughness or harshness in the tone is a sure indication of false-cord interference.*

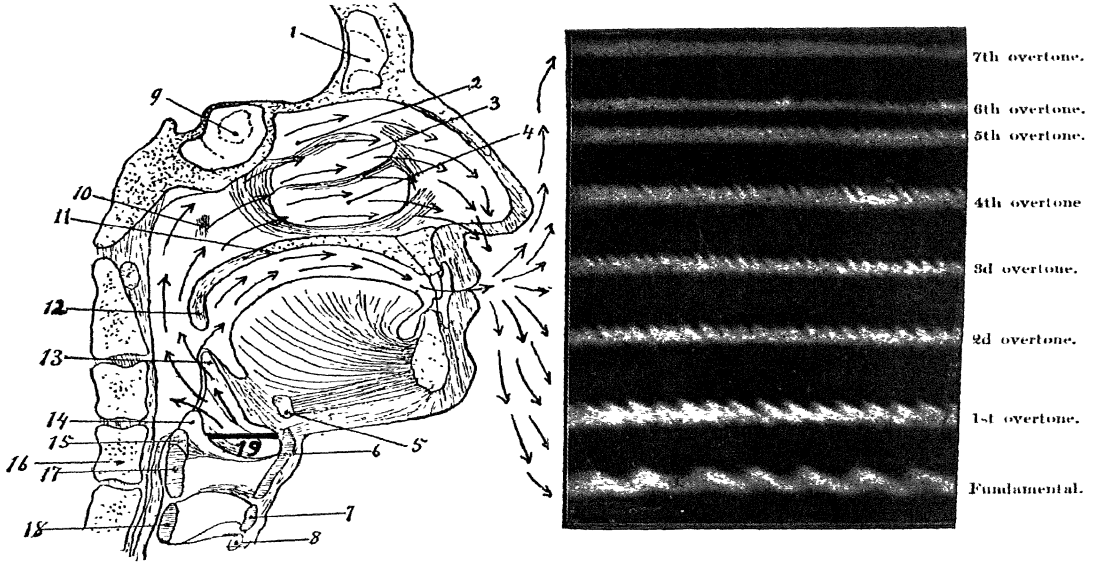
Soft-palate interference consists in the raising of the soft palate against the back of the pharynx, thus shutting off the air-waves from the upper pharynx and nasal cavities. The effect upon volume and quality of this one form of interference can be readily appreciated by a consideration of Figs. 12 and 13.

Fig. 12 shows the action of the mechanism without soft-palate interference and the resulting combination of partial tones.

Fig. 13 shows the contraction of the soft palate by the same singer singing the same vowel and the resulting combination of partial tones.

In Fig. 12 we have full use of the resonance space, and the resulting tone has eight partial tones with the fundamental very strong and the overtones decreasing in strength as they rise in pitch. In Fig. 13 the upper pharynx and nasal cavities are shut off with the result that the four highest overtones are "damped out," the fundamental tone is weakest, and the overtones increase in strength as they rise in pitch.

These analyses are not guesswork but actual measurements of the voice produced by the same singer without and with soft-palate interference. According to these records this one form of interference takes away one-half the volume of the voice, and further deprives the singer of a richness of tone which is his natural gift, and is his if he will simply relax these muscles of the soft palate. It is very clear that the motion of the ear-drum, caused by the impingement of the series of air-waves shown in Fig. 12, must be quite different from the motion caused by the combination of air-waves shown in Fig. 13, both as to the manner and extent of this



The arrows indicate the path taken by the air-waves.

FIG. 12. Vertical section of the head to show location and relative size of the resonance cavities.

1. Frontal sinus. 2, 3, and 4. Turbinated bones 5. Hyoid bone. 6. Thyroid cartilage. 7 and 18. Top ring of the trachea. 9. Sphenoidal sinus 10. Epi-pharynx 11. Hard palate. 12. Soft palate. 13. Epiglottis. 14. Arytenoid cartilage 15. Arytenoideus muscle. 16. Vertebra. 17. Cricoid cartilage. 19. Vocal cords.

motion. The difference in both quality and volume, therefore, between these two tones, must be very great. It can be readily understood that the ear of the listener may be easily trained to appreciate this great difference in quality.

The muscles of the back of the tongue, when they contract, pull the tongue downward and backward. This pushes the epiglottis (13, Fig. 12), which is attached to the base of the tongue, over the larynx, and thus interferes with the air-waves as they emerge from the larynx. This form of interference gives a peculiar "muffled" quality to the tone.

The contraction of all of these muscles, together with those running from the chin to the hyoid bone, interfere with the free motion of the cartilages and muscles of the larynx (pitch mechanism). This form of interference takes away the two most important factors in pitch changes; namely, the lessening of the length and of the weight of the vocal cords (vibrator). The extrinsic or swallowing muscles are much more powerful than

the intrinsic muscles. The strong pulling of the extrinsic muscles, attached to the thyroid cartilage, tends to separate it from the cricoid. This action has the effect of "fixing" the arytenoid cartilages upon the cricoid, thus preventing the rotation of the arytenoids by the "vocal muscles" (*thyro-arytenoidei*).

To sum up the whole matter of interference, we find that it deprives the singer of more than one-half of the capabilities of the vocal structures. The loss to the singer and speaker by this combined interference is something appalling. The fact that every normal mechanism is capable of producing great volume, beautiful quality, and a wide range of pitch if properly used, and that there are so few who even approximate this condition, proves that we do not yet appreciate what are the capabilities of the vocal mechanism.

These two photographs show clearly the difference in the composition of a tone of good quality and great volume and one of poor quality and little volume.

Many of the leading physicists of the world

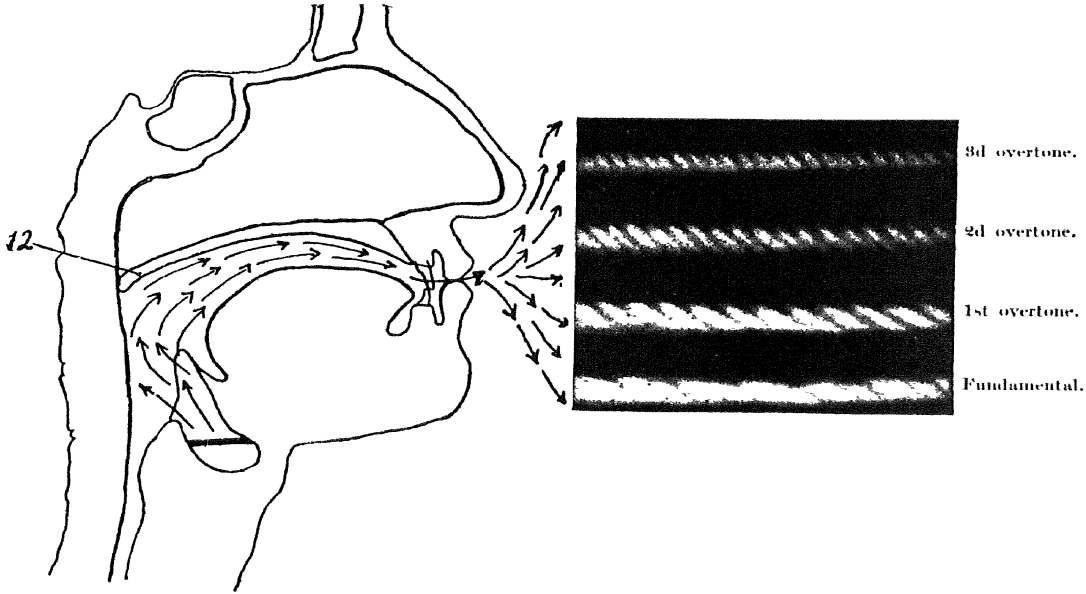


FIG. 13. Vertical section of the head, similar to FIG. 12, but showing how the raising of the soft palate (12) and closing of the passage diminish the space available for resonant re-enforcement by cutting off the large cavity of the upper pharynx and nose.

have seen this voice-analysis apparatus and have acknowledged that it gives accurate results.

A consideration of the whole field of interference shows that our voice mechanism is really hampered in but two ways. The strong action of the extrinsic muscles shuts off resonance space and interferes with the free action of the vocal cords. Correct voice production may be summed up as "non-interference with the action of the vocal cords and full use of resonance," which is our natural law.

Chapter VIII

THE NATURAL METHOD OF VOICE PRODUCTION

METHOD is defined as "the orderly regulation of conduct with a view to the attainment of an end."

The end to be attained by means of the natural method of voice production has been very clearly stated by our natural law, *i. e.*, non-interference with the action of the vocal cords and full use of the resonance space.

The steps taken to reach this desired end depend upon a knowledge of the nature of the mechanism with which we are dealing. The extrinsic or interfering muscles are voluntary, that is, they are directly under the control of the will. It is possible to use each one of the interfering muscles independently of all the others. For example, the soft palate can be raised without pulling down the back of the tongue or contracting the muscles of the false cords.

On the other hand, the intrinsic muscles of the larynx or those directly concerned in voice production are involuntary. Their action is not under the direct control of the will. This action cannot be forced, but must be induced. One of these intrinsic muscles cannot act without the others. For example, we cannot place one of the vocal cords in position for producing tone without the other vocal cord assuming a like position.

This consideration of the nature of the extrinsic and of the intrinsic muscles shows that any attempt *to do anything* with the voice mechanism directly will cause interference and thus prevent the correct action of the mechanism.

Present knowledge of the mechanics of nerve control of voluntary and involuntary action is very meagre. Just how a sense-impression is conveyed from a sense centre to a motor centre and there changed into a motor impulse is absolutely unknown. Until we do know these things, the precise difference in nature between voluntary and involuntary action will remain obscure. The whole field

of psychology of voice production must be based upon conjecture and, therefore, remain an unknown quantity.

From the very nature of things an orderly regulation of conduct for voice development must be in accord with the fundamental facts of voice production—facts which are true for any individual who cares to test them and, hence, are impersonal.

The correct action of the vocal cords depends upon non-interference with their free vibration and the proper functioning of the vocal muscles. The free vibration of the vocal cords is interfered with by the action of the false cords, as has been shown. The proper functioning of the vocal muscles depends, first, upon the relaxation of the extrinsic muscles, particularly the chin muscles and those of the back of the tongue and, second, upon their ability to hold the vocal cords in position against any breath pressure needed for volume, at the same time regulating the length, weight, and tension of the cords for pitch changes. In order to do this, the vocal muscles must be fully developed. This

brings up the whole question of voice development.

As has been stated, the three factors concerned in voice production are the vibrator, the resonance mechanism, and the pitch mechanism. The vocal cords (vibrator) are composed of yellow elastic tissue. No amount of exercise or activity can develop yellow elastic tissue. Therefore, the vocal cords remain the same size and shape throughout the whole course of correct voice development.

On account of long-continued interference with the action of the pitch mechanism by the extrinsic muscles and the consequent overstretching of the vocal cords, we find that the cords become, in reality, too long for the larynx. Moreover, the continued interference of the extrinsic muscles has weakened the vocal muscles. This results in a sagging of the vocal cords, and the glottis remains slightly open during voice production. This condition permits the breath to escape between the cords and is the most frequent cause of "breathy" tone. It is there-

fore evident that when the interference is removed, a proper approximation of the vocal cords by the action of the intrinsic muscles alone is not to be expected in the beginning. However, the use of the mechanism without interference soon allows the vocal cords to regain their normal length and with development of the vocal muscles the proper action of the cords is obtained and the "breathy" tone disappears.

In vocal resonance we have two things to consider, the resonance cavities themselves and the air in these cavities. To develop means to unfold, to increase, to enlarge. All anatomists agree that after maturity is reached, the size and shape of the rigid walls of the pharynx, mouth, and nose remain the same throughout the remainder of life. In the case of the child, these cavities enlarge to the same extent, whether the voice is developed through the growing period or not. Muscular contraction to produce temporary changes in the size and shape of the mouth cavity cannot in any way be considered as a development of resonance. These changes

simply provide different reinforcements to produce the various tone qualities needed for interpretation. If the resonance cavities cannot be developed, then the air in these cavities cannot be increased and the development of resonance is seen to be impossible.

The size and shape of the vocal cords always correspond to the size and shape of the resonance cavities. Any development in either of these would be detrimental rather than beneficial, as this correspondence would be lost.

The cartilages of the larynx cannot be developed. Every factor in the voice mechanism, except the vocal muscles, has been shown incapable of development. The problem of voice development narrows itself down to the development of the vocal muscles.

The principles underlying the development of the vocal muscles are precisely the same as those concerned in the development of any muscle.

The fundamental principle of muscular development is contraction and relaxation without strain. The contraction of the muscle

forces the blood, carrying the carbon-dioxide and other waste products, out of the muscular tissues and the relaxation of the muscle allows the fresh blood with its nourishing elements to enter.

The moment a tone is heard the vocal muscles are fully contracted for that pitch, and the principles of muscular development call for an immediate relaxation of these muscles, which means a stopping of the tone. Short tones provide the alternate contraction and relaxation of the vocal muscles.

Interference is caused by contraction of the extrinsic muscles. Non-interference means relaxation of these muscles during voice production. A muscle is relaxed when it is in a position of rest. The extrinsic muscles are relaxed when the student is breathing quietly through the nose without producing tone. The first thing to be accomplished in the natural method is the production of tone without disturbing this position of rest of the extrinsic muscles. This may be done most easily by producing soft tones with the mouth closed.

Great care should be exercised as to how the tone begins. There are three things to notice about the beginning of the tone. First, the voice must begin absolutely on the pitch. Any sliding up to pitch means false-cord interference. Second, there should be no "jerk" at the beginning of the tone. This—which is sometimes called "the stroke of the glottis" —also indicates false-cord interference. Third, the tone should be entirely free from the so-called "nasal" or "metallic" quality, which likewise means interference of the false cords. If difficulty is experienced in producing the tone without interference, the pupil should be directed to continually diminish his tone until the interference disappears.

As voice quality may perhaps be better studied in the sustained tone, it may be advisable in the beginning to sustain the hum and note carefully the presence or absence of this "nasal" quality. In a properly produced soft hum the tone is practically all fundamental. The overtones are so weak that they have very little influence on the quality. It has been shown in Chapter VI how essential

the strong fundamental tone is to the production of good volume and good quality. We can realize how important it is that the student should have a clear conception of what the strong fundamental tone sounds like. A tone produced by a tuning-fork and its resonator is a pure fundamental tone. A very clear idea of the desired quality of the voice may be gained from listening to the tone produced by a tuning-fork and its resonator. As an appreciation of the proper tone quality is so necessary, particularly in the beginning of voice development, it is very essential that every teacher and every student of voice production should possess such a tuning-fork and resonator. An idea of the proper beginning of the tone may be learned by allowing the vibrating tuning-fork to approach the opening of its resonator slowly.

A clear idea of the great importance of resonance, in volume especially, may be gained from striking the fork and noting the strength of the fundamental tone produced by it alone. Striking it again with the

same force and then applying it to its resonator, the volume is very markedly increased. This is a remarkable demonstration of the relative importance of resonance to the extent of swing of the vibrator in voice production. Resonance will increase volume several hundredfold, while the widest possible swing of the vocal cords can only increase it approximately twentyfold. Full use of resonance in the voice mechanism can only be gained by a relaxation of muscular tissue, particularly the relaxation of the muscles of the soft palate. This means a lessening of expenditure of energy. A wide swing of the cords requires a great increase in the breath pressure, which necessitates a much stronger contraction of the breath-expelling tissues and muscles. This means a great increase in the expenditure of energy. The perfect action of the voice mechanism is that which accomplishes its purposes with the least possible expenditure of energy. We have shown that the wide swing of the cords impairs quality, as under these conditions the various partial tones are not started in their proper relative

intensities for the best quality. The wide swing of the cords is therefore undesirable because it requires increased expenditure of energy, impairs quality, and the ratio of increased volume is comparatively small. On the other hand, full use of the resonance space lessens the expenditure of energy, vastly improves quality, and the ratio of increased volume is comparatively great. The immense importance of full use of the resonance space is thus clearly indicated. The most effective action of the above-mentioned resonance space can only be attained when the proper combination of partial tones is projected into it. As we have seen, this can be done only when there is a moderate and unhampered swing of the vocal cords. The absolute validity of our natural law is thus made very clear.

As soon as the proper tone quality is recognized by the student the tone should be shortened as much as possible, still maintaining the right beginning and right quality.

Both the theory and practise of the present day in muscular development call for

the use of very light weights. The use of heavy weights as producing the best and quickest results in the development of muscular tissue has been discontinued. The soft tone is to the vocal muscles what the light weight is to the muscles of the arm or the leg. Short tones give the greatest number of contractions and relaxations of the vocal muscles in a given length of time. Interference causes overwork and strain of the vocal muscles. Short soft tones without interference give the most desirable and most rapid development of the vocal muscles and therefore form the ideal exercise for voice development.

The loud and sustained tone represents the use of heavy weights, and comparatively long continued contraction of the vocal muscles. It is impossible in the beginning of voice development to produce loud and sustained tones without interference. Such tones overwork the vocal muscles and in time will injure and weaken them. This practise is in reality not a development of the vocal muscles, but of the interfering muscles. Practise

on loud and sustained tones is entirely contrary to the fundamental principle of muscular development, and hence of voice development.

We cannot sing with the mouth closed. The moment we open the mouth during voice production we begin to form vowel sounds. The vowel sound which involves the least disturbance of the position of rest of the extrinsic muscles is *ē* (*ee*).

This ordinarily should be the easiest vowel sound to produce.

As pronunciation of words includes the use of both vowels and consonants, it is desirable to first combine the consonants with the vowel *ē*.

Consonants are more or less complete interruptions of the tone. They are produced by the action of the articulating muscles. These are the muscles of the lips, those which raise the tip of the tongue and the back of the tongue, and those of the soft palate. The only articulating muscles which belong to the extrinsic group are those of the soft palate. The action of the muscles of articula-

tion and of the extrinsic muscles of the larynx are associated during swallowing. This association is very apt to be active during articulation, and thus articulation is a fruitful source of interference with the voice mechanism.

The object of any exercise for voice development is therefore twofold, first to break up the association between the articulating and the extrinsic muscles, and second to develop the intrinsic muscles. In the case of the soft palate, interference is brought in by the production of certain consonants, such as the *t* and *k*, but this interference should be immediately dropped upon the beginning of the tone.

The consonants *m*, *p*, and *b* require the closing of the lips and the shutting off of that part of the tone which is coming through the mouth, so that only the tone which passes behind the soft palate and through the upper pharynx and nasal cavities can be heard. For this reason a combination of the consonant *m* and the vowel *ē* forms an excellent exercise for establishing the low position of

the soft palate. This is the position it assumes when its muscles are completely relaxed. As *m* requires the closing of the mouth, it cannot be articulated unless the soft palate is down, thus allowing the tone to come out only through the nose. If we repeat *m* rapidly enough, the soft palate has not time to go up between times, and hence remains down. The *mē-mē-mē* exercise, which is merely the hum with the motion of the lips added, will therefore establish the low position of the soft palate. The greatest care must be taken in this exercise to keep out the so-called "nasal" quality, which signifies false cord interference and which is so often associated with it. The quality of the tone should frequently be compared with that produced by the tuning-fork and resonator. This latter quality should at all times be heard strongly in every voice tone.

All the consonants may be thus combined with the vowel *ē*, as *tē-tē-tē*, *lē-lē-lē*, *gē-gē-gē*, etc. The use of these exercises, if done without interference, will break up the association of the action of the articulating and extrinsi

muscles, and will aid in the development of the vocal muscles.

As many words begin with vowels, it becomes necessary to establish the correct action of the voice mechanism for the vowel sound without a preceding consonant. The proper production of the vowel sounds, as has been shown, necessitates the low position of the soft palate. After this has been established by the use of the preceding exercises, then the vowel sounds may be practised without the consonants. As *ē* disturbs least the position of rest of the extrinsic muscles, it is found desirable in most cases to begin with this vowel. The tests for nasal resonance, described in Chapter VI, should be used to be certain that the student is securing full use of the resonance space. The quality of the tone should be compared frequently with that of the tuning-fork and resonator. If difficulty is experienced in producing *ē* with nasal resonance, this exercise may be begun with the *mē-mē-mē*, and finished by sustaining the vowel *ē* alone.

After the vowel *ē* can be produced with-

out interference and with full use of resonance, it may be combined with the other vowel sounds. In the beginning the transition from one vowel sound to another should be very gradual, making sure that there is no loss in the strength of the fundamental tone.

As with the vowel *ē*, the others may be combined with *m* to insure the use of nasal resonance and then sustained alone, as *mā-mā-mā—ā*, *mō-mō-mō—ō*, etc. The different consonants may then be combined with the various vowel sounds, as *mē-mā-mä*, *tē-tā-tä*, *lē-lā-lä*, *gē-gā-gä*, etc.

There is always one pitch in every voice where it is easiest for the pupil to get good tone quality. The exercises should all be practised in the beginning on this pitch. Then he can gradually work up and down from this pitch, limiting the practise, however, to those tones without interference.

An exercise is only of value when produced without interference, and song is simply a form of exercise. Practise with strong interference will not develop the vocal muscles,

but will injure them. Practise with slight interference will make development very slow. It must be understood that in the beginning a tone produced without interference will be very small, but will grow stronger as the vocal muscles develop. As the correct action becomes better established, the student may practise on intervals, beginning with the half-tone and gradually increasing to the octave or more.

During the lesson the teacher should not use any fixed intervals with which the student is familiar, such as scales, arpeggios, etc. If the pupil knows what pitch is to follow the one he is producing, he is very likely to get ready to produce this pitch, which is almost sure to cause interference. The pupil's voice should follow the piano, the teacher playing all sorts of odd intervals within his easy range. Without interference the voice will respond immediately to the pitch sounded. With interference it will lag perceptibly if the intervals are sounded rapidly.

The student must remember that practise at all times, even after the voice is fully de-

veloped, should consist of *very* soft tones. The preceding exercises will have prepared the student for work on songs with easy intervals and limited range. The tone quality should always be carefully watched to note the presence of the strong fundamental tone.

The student is advised not to practise too much in the beginning, as the vocal muscles are easily fatigued at this stage of their development. As they grow stronger, the periods of practise may be lengthened.

The time necessary for full development of muscular tissue under favorable conditions, is approximately three years. Practise for three years without interference should give full development of the vocal muscles. When the vocal muscles have been severely injured and weakened by interference, a longer time is necessary.

A student of average intelligence should learn how to do the exercises without interference within a year. Once he has learned to do this, the function of the teacher of voice production is ended. The matter of voice development from then on rests with

the student, as he alone can develop his own vocal muscles.

The exercises described above, *if properly performed*, will give an unhampered action of the vocal cords and full use of the resonance space. The method thus outlined conforms both to the natural law of voice production and to the nature of the mechanism. It may, therefore, be rightfully termed the natural method of voice production.

Chapter IX

THE BREATH IN VOICE PRODUCTION

BREATH is defined as "the air inhaled and exhaled in respiration."

The only function of the breath in voice production is to vibrate the vocal cords, which alone originate all of the air-waves composing the voice. Breath can neither originate the air-waves, determine the rate at which they are originated, nor reinforce them for the production of volume and quality of tone. It is therefore a secondary and not a direct cause in voice production.

"The intercostal muscles are the chief agents in the movement of the ribs in ordinary respiration. The external intercostals raise the ribs, especially their fore part, and so increase the capacity of the chest from before backward. At the same time, they

evert their lower borders and so enlarge the thoracic cavity transversely. The internal intercostals at the side of the thorax depress the ribs and invert their lower borders and so diminish the thoracic cavity. The *levatores costarum* assist the external intercostals in raising the ribs.

"The ordinary action of respiration is merely passive, the resilience of the ribs and elasticity of the lungs being sufficient to produce it. This causes the ascent of the abdominal viscera, covered by the diaphragm. The action of the diaphragm modifies considerably the size of the chest and the position of the thoracic and abdominal viscera. During a forced inspiration the cavity of the thorax is enlarged in the vertical direction from two to three inches, partly by the ascent of the walls of the chest, partly by the descent of the diaphragm.[1] The chest consequently encroaches upon the abdomen; the lungs are expanded and lowered in relation with the ribs nearly two inches, the heart

[1] "This is due to the contraction of the muscular fibres of the diaphragm."—F. S. M.

being drawn down an inch and one-half; the abdominal viscera are also pushed down (the liver to the extent of nearly three inches), so that these organs are no longer protected by the ribs. During expiration, *when the diaphragm is passive*, it is pushed up by the action of the abdominal muscles. The cavity of the abdomen (with the organs contained in it) encroaches upon the chest, by which the lungs and heart are compressed upward and the vertical diameter of the thoracic cavity diminished."[1]

We find that the chief factors in ordinary deep inspiration are the contraction of the external intercostal muscles and of the muscular fibres of the diaphragm. In ordinary expiration the active factors are the resiliency of the ribs and the elasticity of the lung substance. In the beginning of the latter act the muscles of the diaphragm and the external intercostals are relaxed suddenly, so that the breath is quickly expelled. However, during voice production this action is impeded by the gradual relaxation of the external inter-

[1] Gray's *Anatomy*, pp. 394, 397.

costal and diaphragmatic muscles, so that the breath is expelled slowly.

In all ordinary speech and song the above described action of the breath mechanism is sufficient, providing there is no interference with the voice mechanism, as in this case a wide swing of the vocal cords is not necessary. On the other hand, if there is interference with the voice mechanism, or a particularly long phrase needs to be executed, the internal intercostals and the abdominal muscles are brought into action to force up the diaphragm and invert the ribs for a further expulsion of the breath.

The relative importance of resonance to the extent of swing of the vibrator is demonstrated very convincingly in the experiment with the tuning-fork and resonator tuned to its pitch. When the tuning-fork alone is struck, its pitch tone is audible but a few inches. If struck again with the same force so that the extent of vibration of the prongs is practically the same and then applied to its resonator, the tone will be increased in intensity several hundredfold. In a similar

manner, if the vocal cords are vibrating without interference and full use of resonance is secured at the same time, then great volume of voice can be produced with but a small expenditure of breath. If, however, this full use of resonance is not secured, which occurs when the soft palate rises during voice production, thereby shutting off one-half the resonance space, a much wider vibration of the vocal cords must make up for this loss of resonance. This calls for a large expenditure of breath. It is thus evident that without full use of resonance, breathing becomes very important in volume of voice, but that with it breathing is comparatively unimportant.

For these reasons, in the natural method of voice production breathing becomes a secondary consideration. It has been the author's experience that in the beginning the pupil takes in too much breath, and a portion of it has to be expelled before a proper beginning of the tone can be made. On the other hand, a lack of breath during singing or speaking is a sure indication of interference with the voice mechanism.

Aside from a consideration of the importance of breathing in connection with voice production, the author believes that the importance of deep breathing has been greatly overrated in certain quarters.

Doctor D. A. Sargent, director of athletics at Harvard University, writes: "We breathe in response to the demands of the system for more oxygen. Sitting still a man needs only a little air and breathes accordingly. While running, swimming, or taking vigorous exercise the man breathes faster as his system demands more oxygen. What would you think of a locomotive puffing and blowing while standing quietly at the station. Forced draft is only needed when a locomotive is going at high speed and pulling a heavy load. The fatal mistake all 'breathing cranks' make is that no matter how much they breathe, the system can only take up so much as it needs by the effort of the body to keep warm and do its daily work."

The function of the respiratory centre is to regulate the amount of oxygen which is taken into the blood. Too much oxygen burns up

the tissues and is as injurious as too little. It is unwise for the individual to interfere with the function of the respiratory centre and attempt through deep breathing exercises to force too much oxygen into the blood.

Voice production without interference needs only a little breath and the singer or speaker breathes accordingly. When there is interference with the voice mechanism the performer is "pulling a heavy load" and "forced draft" is necessary. Forced breathing means "forced tones" or interference.

Breath has often been defined as the "motive power" in voice production. This is not true. The energy required for the expansion of the chest boundaries is furnished by the contraction of the external intercostals and the muscular fibres of the diaphragm. The resulting expansion of the chest stores up energy in the chest walls and lung substance and this energy forces the breath out during expiration. The motive power then is found not in the breath but in the muscles, expanded chest walls, and lung substance.

The breath performs the same function in voice production that the belt does in conveying power from the motor to the machine which it operates. Breath, by itself, will not vibrate the vocal cords. It must have power applied to it by the energized chest walls and lung substance before it is compressed sufficiently to vibrate the cords. It is this *breath pressure* furnished by the motive power of the respiratory muscles which is the effective agent in vibrating the vocal cords.

In a similar manner the belt will not operate the machine by itself. Only when power is applied to it by the motor will it perform its function.

As singers, particularly those on the operatic stage, are obliged to assume a great variety of positions while singing, any fixed position of the chest is out of the question. In any case, this fixed position is undesirable, as it is likely to cause interference with the voice mechanism.

From the above considerations it would seem that the time devoted to breathing exercises could be much more profitably em-

ployed in breaking up the association between the action of the extrinsic and of the intrinsic muscles and in the development of the latter.

Chapter X

STANDARDIZATION OF VOCAL TERMINOLOGY

TERMINOLOGY is defined as "the terms used in any art, science, or the like."[1]

"Science and art may be said to be investigations of truth. But science inquires for the sake of knowledge, art for the sake of production"[1] (the application of this knowledge).

"Incidental to this difference is a difference in method, science being analytic and critical, while art is synthetic and constructive."[1]

"In the matter which makes up the body of the two an art involves the means of discipline in the use of the knowledge which may have been furnished by a corresponding science. The more complete the scientific basis of an art the more perfect the art."[1]

[1] *The Century Dictionary.*

"Terminology is sometimes restricted to the terms employed to describe the characters of things as distinguished from their names, or a nomenclature."[1]

"Term, from terminus, a boundary, signifies any word that has a specific or limited meaning. Science fixes terms."[2]

"Terms of art admit of no change after the signification is fully defined."[1]

"The precision of a writer depends upon the choice of his terms."[2]

It is apparent from these quotations that the same terms must be used both in the science and the art of voice production. It is also evident that a term to be of any value to the teacher or student must describe either some characteristic of the voice as it affects the listener or some attribute of the mechanism which produces the voice. Every term must have some specific or limited meaning, as applied to the voice or its mechanism. Any term which does not perform this function has no place in vocal terminology.

[1] *The Century Dictionary.* [2] Crabb's *English Synonyms.*

The properly used term concentrates the mind upon the nature of the voice or of the mechanism. For example, the word *quality* brings to mind the number and relative intensities of the partial tones and the manner in which they affect the ear-drum of the listener. This term describes a definite characteristic of the voice itself. The term *vibrator* recalls the vocal cords and their action in the origination of the several partial tones which compose the voice. *Vibrator* describes an attribute of the mechanism and shows the relation of the vocal cords to the production of tone. The right of these terms *quality* and *vibrator* to a place in vocal terminology is thus established.

An improperly used term takes the mind away from the voice and the mechanism and centres it upon something not directly concerned with either. For example, the term psychology directs the attention to the various activities of the mind, the brain, the nerve-centres and their connecting fibres, and to the manner of transmission of the impulses from one centre to another.

The purpose of this chapter is not to ridicule the present terminology or those who use it. The writer wishes to show that the great majority of present terms do not describe the voice or the mechanism and hence are useless and cannot be standardized, and, second, that most of the terms lead directly to interference with the voice mechanism. The greatest need of the voice-teaching profession to-day is the establishment of a series of terms which have definite or standard meanings. Standardization of terms employed in voice teaching will enable teachers to understand each other and pupils to grasp the ideas to be conveyed. This condition is necessary before any subject can be discussed intelligently and with understanding. Any real scientific (practical) terminology is based on this idea. Every term means one thing and *one thing only*, so that the moment a particular term is heard the same idea is present in the minds of both speaker and listener.

Without a standard terminology, the condition of understanding of a subject parallels the biblical account of the building of the

Tower of Babel. Each worker spoke a different tongue and there was consequently no understanding and no advancement. Any standard voice term must in some way describe the voice or the voice mechanism. The only terms which can do this are those which describe pitch, volume, and quality of the voice and the action of the voice mechanism.

Without standardization of voice terms the registration of voice teachers is powerless to discriminate between the competent voice teacher and the fake voice teacher.

The present definitions of the voice by teachers, critics, and others show that they cannot appreciate the nature of the voice. Voice is variously defined as "vocalized breath," "vibrated breath," "vitalized breath," "gift of God," "product of the mind," etc. The voice is air-waves, which, like those of any other sound, travel at the rate of 1,100 feet per second or about 750 miles per hour. Breath is an air-current, and air-currents travelling at the rate of 750 miles per hour would destroy everything in their path. This conception of the nature of

the voice is false. If it were true, a mere sound would raze any structure or destroy any living creature in its path. The breath can no more be "vitalized" than can wood or stone. The voice is no more a "gift of God" than is the tone from any other musical instrument, like a piano or violin. Every voice mechanism, if correctly used, will produce beautiful tone. Therefore, a beautiful voice is not a special dispensation of divine Providence.

There exists a very popular conception of the voice as something psychological, namely, that voice production is a product of the mind. On this point the *Century Dictionary* tells us that "examples of actual energy are the energy of sensible motion, as in a moving cannon-ball, sound-waves, and of heat." According to this, the voice being sound-waves, is an "example of actual physical energy." In their latest book on *The Elements of Physiological Psychology* the two leading authorities in America to-day state "the so-called mind is not the kind of existence in which physical energy can be stored up or

to which it can be transferred or from which it can be derived. The popular conception of energy as a sort of entity that can actually be split up and distributed or passed over is of course especially absurd when considered as applied to the relations of the body and the mind."

If the voice is a product of the mind, then the brain must contain the three elements of the voice mechanism, namely, vibrator, pitch mechanism, and resonance mechanism. Such a conception is ridiculous. The brain is the organ of the mind. Without the brain there would be no mind. The brain is composed of nerve-centres and nerve-fibres which connect them. The principal forms of nerve-centres are the sense centres, the association centres, and the motor centres. Those who write about the psychology of voice production do not mention nerve-centres and their connections or make any attempt to trace out the manner in which a sense-impression is transferred from a sense centre to a motor centre, and from there to the muscles whose action is necessary in voice production.

A rational psychological method would require a clear description of how these things happen. Our greatest psychologists acknowledge that nothing definite is known as to how they occur. The theory is that in voluntary action the impression made upon the sense centre is conveyed first to the association centre, where some indefinite mental process is carried on. From here the impression is transferred to the motor centres, and thence through the nerves to the muscular structures. In involuntary action, with which we are largely concerned in voice production, the sense-impression is supposed to be transferred from the sense centre directly to the motor centre in some unknown manner. As there is a right way and a wrong way for the voice mechanism to act, then in the psychological method there must be a right way and a wrong way to transmit the impulses from the sense centre to the motor centre. This would involve on the part of the teacher of the psychological method the ability to instruct his pupils how to send these mental impulses in the right way.

There are, however, no fundamental facts upon which to base these theories or practises and no possible way to demonstrate their validity. If such a thing as a psychological method of voice production were possible it would of necessity be based upon conjecture and not upon real knowledge.

An idea has recently sprung up that in the development of muscles or technic the student needs only to concentrate the mind upon the particular action required and his muscles will acquire their necessary strength and agility. It has been definitely established that every muscular development necessitates a corresponding change in its motor centre and that this change is dependent upon the action of the muscle itself. Therefore, the development of the muscle and of the motor centre which controls it progresses together. If a muscle which has once been developed should, through lack of use, lose its strength, the nerve-centre which controls it must be re-educated through the action of the muscle in order to regain its former proficiency.

The idea that the mere concentration of

the mind upon an action will develop the muscles so that they will perform that action is contrary to all our past experience. Any conception of voice production which ignores a mechanism does not recognize interference with the voice mechanism. Unless interference is recognized it will not be removed. So far as eliminating interference is concerned, the so-called psychological method is therefore hopeless, as the prime qualification of the vocal teacher is the ability to detect and eliminate interference.

Physiology plays but a minor part in the method of voice production and can never be a method in itself, as it merely describes the functions of the vocal muscles and cartilages in pitch changes.

"Voice placing" is a favorite term with many teachers. The word place implies a state of rest. Voice (air-waves) is motion and ceases when placed or brought to rest. This idea of "voice placing" is therefore false and impossible of standardization. That conception of the voice which permits it to be "placed" in any particular way or location,

is not only erroneous, but like other false conceptions leads to wrong teaching. "Voice placing" carries with it the idea of *doing something* with the mechanism. Erroneous conceptions like "voice placing" lead directly to interference or wrong action, and correct action of the mechanism can never be attained under these conditions. These wrong conceptions show ignorance of the nature of the voice mechanism.

The present descriptions of tone qualities are not based on facts, but are purely figurative and fanciful. "Tone color" is a term which is frequently used by teachers, critics, and students. Some claim that "*color*" and *quality* as applied to a description of a tone are synonymous. In such a case the word *color* is superfluous, as the term *quality* is sufficient to describe the number and relative intensities of the partial tones. A multiplication of terms having the same meaning is confusing and does not lend itself to clear thinking and concise description.

On the other hand, there are many who use the term "color" in its literal sense. For

instance, a New York orchestra, at great expense, recently attempted to reproduce in color the combinations of tones produced by various instruments. The result of this performance was to distract the minds of the audience, so they could enjoy neither the sound nor the color effects. A very unsatisfactory impression was made. If the attention is divided between two equally important and distinct sets of sense-impressions, such as those of sight and hearing, then no definite impression of either can be gained.

There appeared in a recent number of a musical journal the following table of equivalents between the tone, the color, and the mental attribute.

C	= Red	= Power.
D	= Orange	= Energy.
E	= Yellow	= Intellect.
F	= Green	= Sympathy.
G	= Blue	= Devotion.
A	= Indigo	= Selfless Love.
B	= Violet	= Psychism.

Each note has its own hue, and therefore it is quite correct to state that a musical work has absolute colors pertaining to itself. The table here set forth gives each note and its corresponding color vibration, with its emotional attribute attached. The semi-tones are, as may be readily imagined, a midway shade between the colors.

We cannot mistake the meaning of this table and the accompanying explanation. Let us consider the fundamental facts which differentiate between sound and color. Sound is air-waves. Color is ether-waves. Air is a perception. Ether is a conception. Ether has not yet been transferred to the field of perceptual experience, and probably never will be. Air-waves travel 1,100 feet per second, ether-waves 186,000 miles per second. Sound is appreciated by the ear, color is appreciated by the eye. The structure of these two sense-organs is radically different, so that neither can perform the function of the other.

C_1 equals 128 vibrations per second. Red equals 435,000,000,000,000 vibrations per second. When we can make 128 equal 435,000,000,000,000; when we can make one-fifth equal 186,000; when we can devolve our sense-organs so that the eye and ear will perform the same function; when we can merge perception and conception, then we can consistently use color terms in a rational discussion of the voice.

The voice has three characteristics: pitch,

volume, and quality. Any facts pertaining to voice production must fall under one of these three classes. Such terms as "head voice," "middle voice," "chest voice," and "diaphragmatic voice" are in constant use by teachers, critics, and students. There is no mechanism in the head or the chest or the diaphragm for producing tone. This would involve a vibrator, a pitch mechanism, and a resonance mechanism. Such conceptions are at variance with our sense-impressions. These tell us that we have but one mechanism in the human economy for producing tone. This has the vocal cords for a vibrator, the cartilages and muscles of the larynx for a pitch mechanism, and the cavities of the pharynx, mouth, and nose for a resonance mechanism. These terms are used by some to describe a certain range of pitch. For example, "chest voice" is applied to the low range of the voice, "middle voice" to the middle range, and "head voice" to the upper range. This would place these terms in the pitch class. We have seen that the larynx is the pitch mechanism and that all pitch phenomena are controlled

here. Hence these terms have no place in the pitch class. The same difficulty appears when we attempt to place them in either volume or quality. They fall outside of any rational discussion of the voice.

"Voice focus" is another term frequently used. In order to focus air-waves we must have at least one wave-length of each series to deal with. The air-waves composing vocal tone vary in length from about seventeen feet to about one foot. The distance from the vocal cords, where these tones are originated, to the lips or nostrils, where the voice mechanism ends, is approximately six inches. Before we can adopt the term "voice focus" it must be shown how air-waves varying in length from seventeen feet to one foot may be focussed within a distance of six inches. "Voice focus" does not as yet fit in with our experience.

The terms "pure" and "neutralized" vowels are often used. Acoustics tells us that a pure tone is a simple tone. In the language of acoustics a "pure vowel" would read a "simple complex tone," which is a contradic-

tion. As the voice is always complex, it is impossible for the voice mechanism to produce a "pure vowel."

Every air-wave has a phase of condensation and a phase of rarefaction. When the phase of condensation of one air-wave coincides with the phase of rarefaction of another air-wave of equal intensity, then these air-waves are said to be neutralized and there is no sound. A "neutralized vowel" then equals nothing.

Before any word is used in voice terminology, its meaning must be found to be in accord with the fundamental facts of voice production.

"Register" is a term in common use by the teacher, critic, and student. This word is defined as a record, but it is very evident that this is not its meaning when used in voice terminology. The writer has often attempted to get a definition of this term from the vocal teacher. At a recent gathering of voice teachers a persistent effort on the part of the writer to get a definition of "register" from a representative of the leading teacher abroad resulted in a statement that "register

is resonance." According to this, "register" would mean the sympathetic vibration of the air in the cavities of the pharynx, mouth, and nose.

However, what can be gathered from books on the voice shows that a "register" refers to a certain action of the mechanism. For example, the "chest register" is due to a certain action of the mechanism not defined. The "middle register" refers to quite a different action not yet defined, and the "head register" to a still different action, also not yet defined.

In the chapter on "Pitch" it is seen that a range of three octaves may be produced without any change in the action of the mechanism. This range is produced by the action of two muscles, the vocal (*thyro-arytenoideus*) and the crico-thyroid muscles. The only difference in the action of the mechanism for the production of high and low tones is in the degree of contraction of these two muscles. There is, therefore, in correct voice production, no change in the action of mechanism, and hence no "registers." In other words,

"registers" mean wrong production, or production with interference.

The difficulty with voice terminology at present is that practically all terms are figurative. They have no definite meaning when applied to a description of the voice or of the mechanism. They may be interpreted to suit the fancy of the user. Before the meaning of a figurative term can be of service, it must be translated into an exact term. As a figurative term has several meanings, its special meaning must be defined each time it is used. For example, the term "head voice" is sometimes used to describe a certain range of pitch, sometimes a certain quality, and again to define the mechanism. Such a term does not describe because it is not based on any fundamental fact of voice production. There is no pitch mechanism in the head, tone quality is not determined in the head, and there is also no tone-producing mechanism in the head.

It is excellent practise for voice teachers, students, and critics to test the various terms used in voice description, as has been done

above. The following list affords material for such study: Warm, cold, dry, acid, sour, white, dark, sombre, golden, mixed, brilliant, limpid, liquid, flat, wooden, unvibrant, thin, thick, open, covered, throaty, loose, breathy, spiritual, muscular, earthy, heavy, ethereal.

The terms enumerated above are in common use. They do not describe the voice or the action of the mechanism, and hence simply confuse the mind of the student and public. There is no possibility of agreement as to the meaning of such terms, and therefore standardization of them is impossible.

The terms which in reality describe the voice and the mechanism have a definite meaning upon which all can agree, and hence can be standardized. It is thus seen that standardization of voice production cannot be accomplished until we have a correct voice terminology.

The appreciation of correct voice production by the general public is a very important factor in bringing about a better use of the voice mechanism by our public singers and speakers. What the public demands it will

get. The creators of the public demand are the critics. They form a court of last resort, before which the singer or speaker must appear. The dictum of this court is accepted by the public as final.

In courts of law the judges in rendering a decision weigh carefully the meaning of every word. Often the decision of a most important case hinges upon the meaning of a single word. For these reasons the singer and speaker should demand definite meanings for the terms used in judging them, in other words, they should demand real criticism.

In Crabb's *English Synonyms* we read as follows: "*Criticism* consists in minutely examining the intrinsic characteristics and appreciating each individually and the whole collectively. It refers to matters of science and learning. *Censure* requires no more than simple assertion. Its justice or propriety often rests on the authority of the individual. *Criticism* is altogether argumentative and illustrative. It takes nothing for granted. It analyzes and decomposes. It compares and combines. It asserts and supports the asser-

tions. The office of the *censurer* is the easier and less honorable of the two. It may be assumed by ignorance and impertinence. It may be performed for the purpose of indulging an angry or imperious temper. The office of the *critic* is both arduous and honorable. It cannot be filled by any one incompetent for the charge without exposing his arrogance and folly to merited contempt."

According to this quotation, if the voice production of a singer or speaker is faulty, the critic should not only be able to point out the fault to the public and performer, but he should also indicate the manner in which this fault could be removed. To do this, specific terms must be used. Terms which describe not only some characteristic of the voice itself, but also the action of the mechanism which produces it. The ear of the critic should be trained to recognize what is lacking in the composition of the tone, and he should be able to state what action of the mechanism causes this.

In order to examine "the intrinsic characteristics" of the voice, and "appreciate

the merits of each part individually and the whole collectively," voice analysis is necessary. Photographic voice analysis has demonstrated that good quality requires the presence of a strong fundamental tone and that the production of the strong fundamental necessitates the free vibration of the vocal cords and full use of resonance. The ear of the critic may be readily trained to analyze the voice, *i. e.*, to recognize the presence or absence of this strong fundamental in the voice tone. His ear may also be easily trained to distinguish whether the lack of the strong fundamental is due to the interference with the vibration of the vocal cords (false-cord interference) or to the shutting off of the upper resonance cavities by the raising of the soft palate (soft-palate interference). Why should not the critic tell the singer or speaker exactly what is wrong with the action of the mechanism?

Voice criticism to-day is not real criticism, but merely praise or censure. It does not aid the performer to improve his production or educate the public to appreciate the differ-

ence between good and bad voice production. It leaves the singer and speaker at the mercy of the mood of the critic. If a critic were required to give reasons for his statements he would be much more careful in expressing his opinions. In writing of authors, Addison says: "Many an author has been dejected at the censure of one whom he has looked upon as an idiot." The writer does not mean to imply from the above quotation that the newspaper critics are idiots, for he knows them to be cultured gentlemen. He does, however, contend that their voice criticisms are for the most part idiotic.

One of the leading newspaper critics has begun a campaign against the voice production heard at the Metropolitan Opera House in New York City. He has termed it "bawling and screaming." He is perfectly correct in these statements, as most of the voice production heard there is atrocious. It is not just, however, to condemn a performance without suggesting how it can be improved. If the critics were to analyze the tone production of each singer individually, pointing

out the various faults to be corrected, the singer could take this criticism to his teacher. If the teacher did not know how to correct this fault he or the singer would make it his business to find out. Such criticism would effect a gradual improvement in the voice production of those who appear in public.

Under the present practise voice production is going from bad to worse, and the fault lies largely in the manner of criticising a performance.

The voice teacher should be a critic *par excellence.*

It may be pointed out to the reader that in the writing of this book the course indicated by the quotations at the head of this chapter has been faithfully pursued. The truth has been reached in the field of voice production through the application of the scientific method of investigation to the fundamental facts of voice production. The knowledge thus gained has been applied to the construction of the natural method. The use of the terms employed has been restricted to those which describe the character of the

voice itself and the nature of the mechanism which produces it. The meaning of these terms has been definitely established by the anatomist, the physiologist, and the physicist. They have been evolved from the combined experience of the past and formulated by our greatest minds.

These terms will stand the test of experience until the very nature of our perceptive and reasoning faculties has been radically changed. For these reasons they may be readily accepted by all thinking people and, therefore, form a permanent basis for the standardization of voice production.

Appendix I

ANALYSES OF FAMOUS VOICES

AFTER our discovery that the voice mechanism was a stringed instrument it became essential to photograph the vocal cords while producing tone in order to show the lessening of the length of the vibrating cords in raising the pitch. We found much difficulty in doing this. We experimented with many kinds of lights—the oxy-calcium, powerful electric, acetylene—and finally found that sunlight was the only one which gave us definite results. We tried the various cameras in the physics laboratory at Columbia without success and finally were obliged to design a special camera for this purpose. It was necessary to build three of these cameras before we obtained one which gave the desired photographs.

Fig. 14 gives a general view of this camera, showing the position of the singer, the reflector, *a*, for throwing the band of sunlight

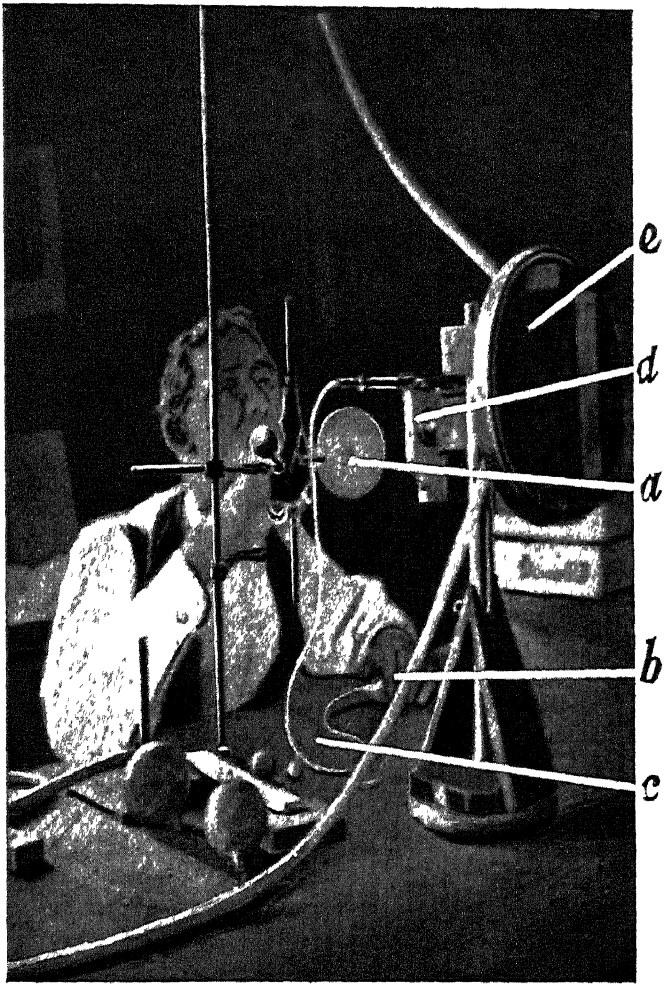


FIG. 14. View of camera showing position of singer.

a, reflector; *b*, bulb; *c*, tube; *d*, automatic shutter; *e*, revolving plate-holder at the back.

into the throat, the bulb, *b*, and tube, *c*, for the automatic shutter, *d*, and the revolving plate-holder, *e*, at the back of the camera.

A heliostat was placed outside the window, which directed the band of sunlight against the reflector, *a*.

Fig. 15 gives a front view of the camera, showing the reflector, *a*, and the automatic shutter, *d*, which is closed. A small mirror, *f*, was fastened to the shutter, *d*, which was placed directly in front of the lens. This arrangement enabled the singer to determine when conditions were favorable for taking the photograph.

It may be interesting to trace out the path of the band of sunlight which was finally projected against the sensitive plate. The mirror of the heliostat, which is arranged to move with the sun, directs the band of sunlight against the reflector, *a*. The latter deflects it against the mirror which has been placed in the throat of the singer. The throat mirror again deflects it into the larynx, giving an image in the throat mirror of the interior of the larynx. The rays of light are reflected

from the larynx to the throat mirror again, and from there to the mirror on the shutter of the camera, where the image of the larynx is seen by the singer. When everything is working satisfactorily the bulb, *b*, is compressed by the singer, as shown in Fig. 16, and the exposure is made. The photographic plate is placed in the revolving plate-holder so that but one-quarter of the plate is exposed at one time. We were thus enabled by revolving the plate-holder to take four pictures on the same plate.

The author herewith presents photographs of the voices of great artists and so-called authorities on voice production for the sole purpose of proving the statements which he made in a previous chapter, that even our greatest artists have very faulty tone production and that the so-called authorities have no real knowledge of correct voice production. There is no desire on the part of the author to belittle the work of our great artists or of other investigators in this field, but he does wish to impress strongly on the mind of the reader that much remains to be learned

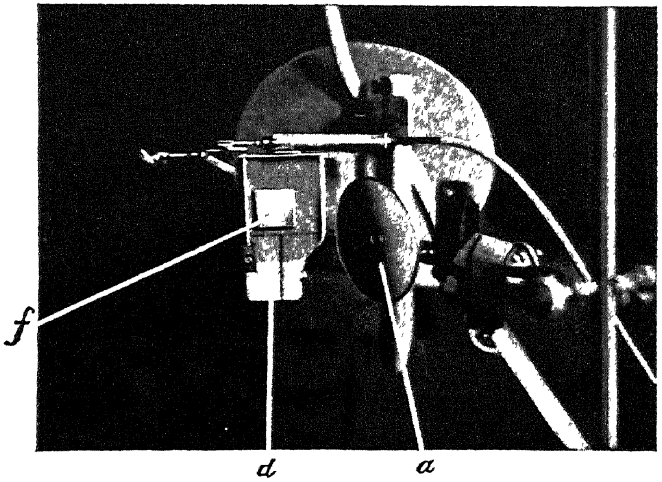


FIG. 15. Front view of camera.

a, reflector; *d*, automatic shutter; *f*, small mirror.

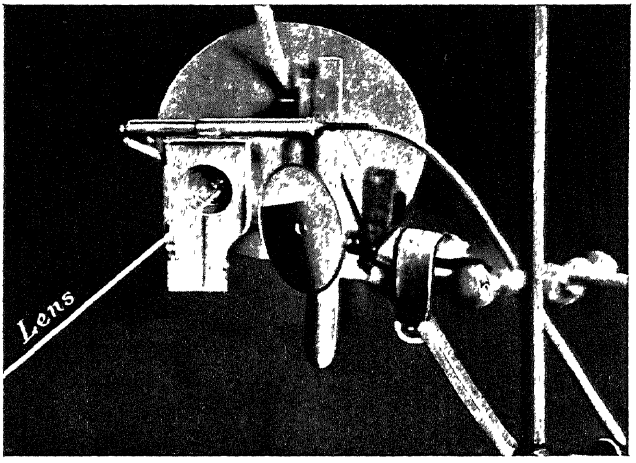


FIG. 16. View of camera showing lens open.

by the artist, the voice teacher, the student, and the critic before all the capabilities of the voice mechanism are utilized by the singer and speaker. Some of our best critics and teachers are beginning to realize the truth of this statement.

In spite of the fatigue and rush of the close of a Metropolitan Opera season, most of the greatest artists kindly consented to sing a few tones into our inartistic apparatus and enable us to put the final test to our idea as to what constitutes a good tone. It must be remembered that these artists acted under unaccustomed difficulties. It is not for them to sing a single tone into a box. Their forte is to thrill an audience. Moreover, the depth of the serrations must be compared in each photograph by itself, because, had the singer produced a louder tone or nearer to the apparatus, all the serrations would have been more pronounced; for example, we can draw only a very poor conclusion as to the strength of a voice from our photograph, but we can judge its character. In order to see the waves in the fundamental clearly, the picture should

be looked at obliquely. In the ladies' voices the difficulty is still greater because, singing an octave higher than our fundamental, the apparatus can record only three overtones.

Fig. 17 shows an analysis of Jean de Reszke's *ä*. This combination of partial tones is typical of soft-palate interference with slight false-cord interference. We have here a comparatively weak fundamental with the overtones increasing in intensity as they rise in pitch. The four upper overtones are lacking. This is very similar to the analysis in Fig. 13 showing the effect of soft-palate interference. According to an authorized representative of Jean de Reszke, the raised soft palate is a cardinal principle of the de Reszke method.

This photograph (Fig. 17) shows that Jean de Reszke at least practises what he preaches.

Fig. 18 is an analysis of Edouard de Reszke's *ä*. This shows soft palate as well as strong false cord interference since the overtones are relatively much stronger than the fundamental as compared with Fig. 17.

Jean and Edouard de Reszke were perhaps the greatest artists who ever sang before the

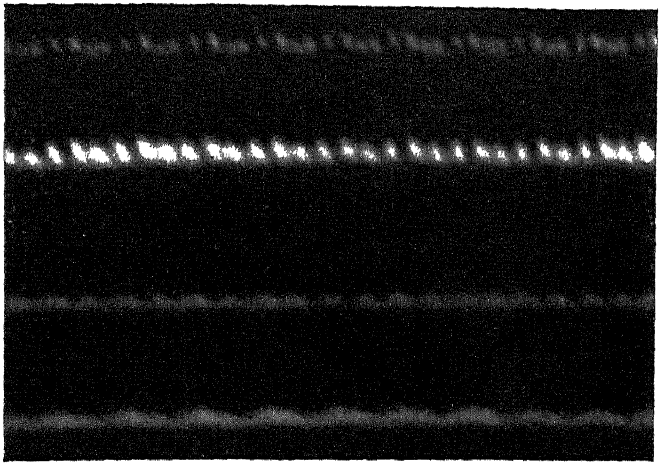


FIG. 17. Jean de Reszke's *ä*.

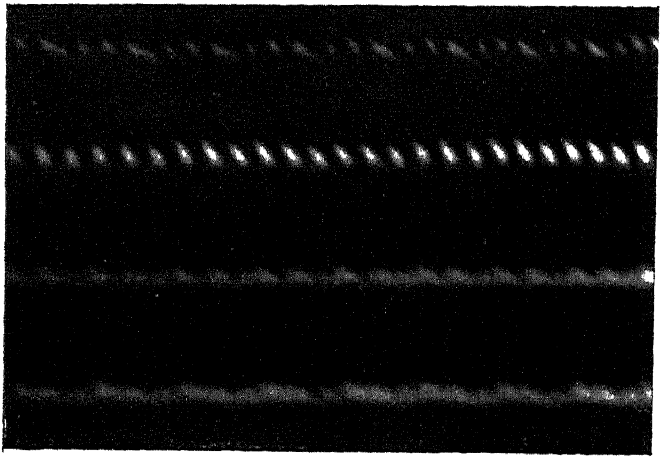


FIG. 18. Edouard de Reszke's *ä*.

public. They seemed to possess every qualification essential to the highest artistic success with the exception of the correct use of the voice mechanism. They had the physique, the stage presence, the intelligence, and wonderful voice mechanisms. With a correct use of the latter they not only might have been singing in public to-day, but their artistry would have been something marvellous. The strong false-cord interference in Edouard's voice had the effect of weakening his vocal muscles and rendering his tones harsh and off pitch, so that his voice gave out before Jean's.

Fig. 19 is an analysis of Scalchi's *ä*. This shows soft palate and strong false cord interference. The wavy appearance of the second line is due to the flaring of the flame and not to any action of the tone upon it. Scalchi's voice was harsh with a very decided "break" in the middle of the range. Here was a wonderful mechanism soon crippled by strong interference.

Fig. 20 is an analysis of Nordica's *ä*. This shows soft-palate interference with comparatively little false-cord interference. At that

time her voice had a very pleasing quality but did not have the fulness or richness which a stronger fundamental and the higher overtones would have given it.

Fig. 21 is an analysis of Calvé's *ä*. This shows soft palate and strong false cord interference. These interferences explain the fact that Calvé's voice was less pleasing than Nordica's and, on account of stronger false-cord interference, gave out much more quickly.

Fig. 22 is an analysis of Arimondi's *ä*. This shows a very weak fundamental and two comparatively strong overtones, indicating soft palate and very decided false cord interference. Arimondi's voice was not impressive and his vocal career was cut very short by his strong false-cord interference.

Fig. 23 is an analysis of Ancona's *ä*. Ancona was a high barytone with a decided "nasal" quality in his tones. This analysis indicates strong false-cord interference accompanied by soft-palate interference.

Fig. 24 is an analysis of Doctor Holbrook Curtis's *ä*. Doctor Curtis claimed to have used this tone as a model in the training of

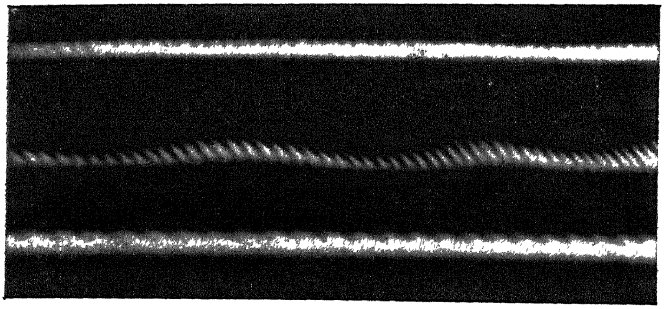


FIG. 19. Scalchi's *ä*.

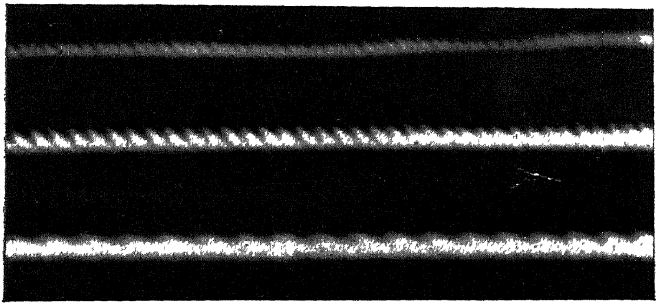


FIG. 20. Nordica's *ä*.

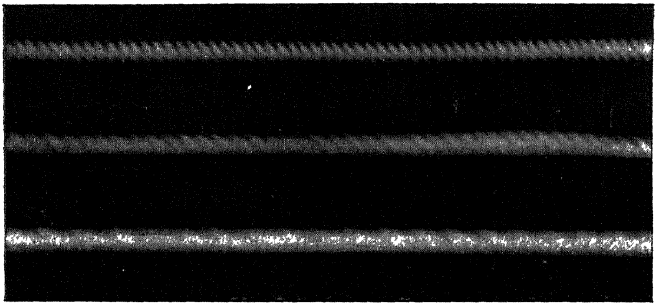


FIG. 21. Calvé's *à*.

Jean and Edouard de Reszke, Melba, Nordica, and other great singers. He also stated before the American Laryngological Society that he had produced this tone for the Academy of Science in Paris, which accepted it as a standard of correct tone production. This analysis shows only a trace of the fundamental tone. The second overtone is so strong that the flames are entirely separated on the plate and it has forced itself through all the resonators except the one for the first overtone. Doctor Curtis is supposed to be our greatest authority on voice production. He is quoted by practically all writers on the throat and nose. His "model" tone is the poorest one which we ever photographed and shows the worst use of the mechanism. This proves the author's contention that heretofore nothing has really been known about the correct action of the voice mechanism or what combination of partial tones should be taken as a standard.

The author contends that every voice mechanism is capable of producing beautiful tones, that the difficulty lies in the action of

the mechanism and not in its structure. This was very clearly shown in the case of one of the Fiske Jubilee singers. This man was a bass. There were sixteen singers in all, and they were accompanied by a large pipe-organ. Ordinarily a pipe-organ covers up the bass voices. This voice when singing with the chorus not only covered up the pipe-organ, but all the rest of the singers. It had wonderful volume and beautiful quality. Edouard de Reszke's voice at its best could not compare with this one in either volume or quality. When this man sang a solo his voice was only mediocre. Nothing but interference could account for such different results during the same evening. While singing in the chorus the action of the mechanism was absolutely unhampered, and the singer was making full use of all its capabilities. When singing his solo he attempted to control the mechanism and the great volume and beautiful quality were consequently lost.

The author inferred that this singer must have large resonance cavities in order to produce such wonderful volume of tone. Sub-

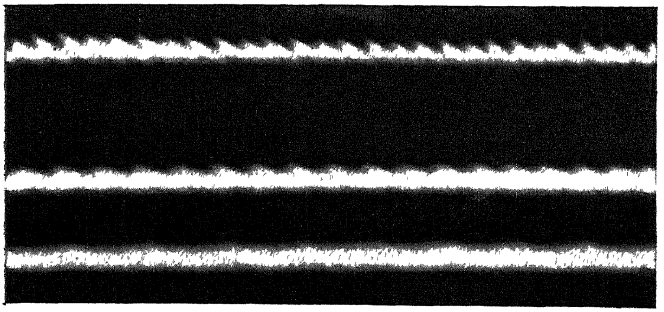


FIG. 22. Arimondi's *ä*.

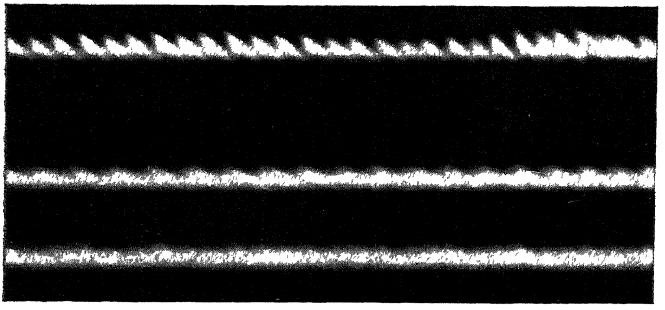


FIG. 23. Ancona's *ä*.

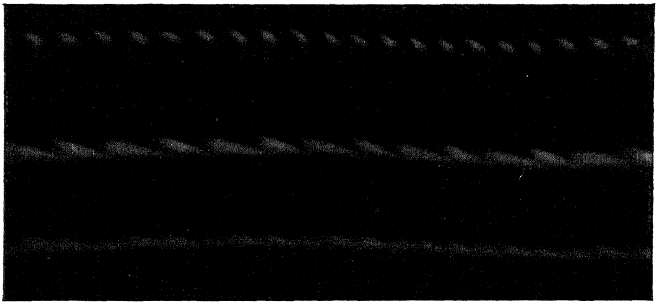


FIG. 24. Dr. Holbrook Curtis's *ä*.

sequent examination of his throat and nose showed nothing extraordinary about the size or shape of his resonance cavities. This is conclusive proof that correct action of the mechanism is the all-important thing in voice production.

The fact that incorrect use cripples the voice mechanism is particularly well illustrated in the case of Campanini. The author had the opportunity of examining Campanini's throat after his voice failed. The vocal cords were thickened and congested, in fact the whole larynx was a mass of infiltration (thickening of the tissues), the arytenoid cartilages were thickened and thus hampered in their motion. The vocal muscles were weakened to such an extent that there was a faulty approximation of the vocal cords. His attempts at tone production were pitiful to listen to. Here was a man in the prime of life, with wonderful interpretative ability and a beautiful natural voice, whose career was cut short by faulty use of the mechanism. A realization of this fact shortened his life and he really died of a broken heart. This is only

one of thousands of similar instances. Is it not time that the teacher, the student, and the critic should realize that there is a right use of the voice mechanism, and that this right use is the thing of greatest importance to the singer and the speaker?

Appendix II

STANDARDS OF VOICE PRODUCTION

THE following fundamental principles of voice production (formulated by the author) were submitted by the National Association of Teachers of Singing to the New York State Music Teachers Convention and adopted by it June, 1915:

Standards of Voice Production

From the Standpoint of the Listener

I. Sound is a sensation produced through the organ of hearing by means of air-waves.

II. Pitch is that characteristic of the sensation of sound which depends upon the rate at which the air-waves strike the ear-drum.

III. Volume is that characteristic of the sensation of sound which depends upon the extent of motion of the ear-drum.

IV. Quality is that characteristic of the sensation of sound which depends upon the manner of motion of the ear-drum.

From the Standpoint of the Producer

V. Voice is sound or air-waves. Vocal tone is always complex, being composed of several simple tones (fundamental and overtones), varying in pitch and in intensity.

VI. Voice production is sound or air-wave production.

VII. Sound, air-wave, or voice production necessitates the use of a mechanism which has three essential elements:

1. A vibrator to originate the air-waves.

2. A pitch mechanism to determine the rate at which the air-waves are originated.

3. A resonance mechanism to reinforce the air-waves started by the vibrator.

VIII. In the voice mechanism the vocal cords serve as the vibrator; the cartilages and muscles of the larynx form the pitch mechanism; and the cavities of the pharynx, mouth, and nose form the resonance mechanism.

IX. Pitch of the voice is determined by the length, weight, and tension of the vocal cords.

X. Volume of voice depends upon the extent of vibration of the vocal cords, which

is caused by breath pressure, and upon resonance.

XI. Quality of voice depends upon the vibration of the vocal cords as a whole and in segments, and upon resonance.

XII. Vocal resonance, which is by far the most important factor in voice production, is due to the sympathetic vibration of the air in the resonance cavities.

XIII. Resonance is more important than breath pressure in relation to volume of tone and more important than the segmentation of the vocal cords in reference to quality.

XIV. Correct voice production, or the action of the mechanism which produces the perfect vocal tone, consists in the free vibration of the vocal cords, the free motion of the cartilages and muscles of the larynx, and full use of the resonance space. This action produces the natural voice, or the voice which nature intended a particular mechanism to produce.

XV. Any muscular contraction which prevents the free vibration of the vocal cords, the free motion of the cartilages and muscles of

the larynx, and full use of the resonance space is termed an interference.

XVI. The principal forms of interference are:

1. The contraction of the muscular fibres of the false cords, which prevents the free vibration of the vocal cords.

2. The contraction of the muscles of the soft palate, which prevents the use of at least one-half the resonance space.

3. The contraction of the muscles of the chin and of the back of the tongue, which prevents the correct action of the pitch mechanism.

XVII. Every form of interference leaves its impress on the quality of the tone. The ear of the teacher must be trained to hear in the tone quality the interference with the mechanism. This is the first step in the removal of interference.

XVIII. The ability to remove interference is based upon a knowledge of the nature of the vocal muscles and of the interfering muscles, viz., the vocal muscles are involuntary and the interfering muscles are volun-

tary. Correct action of the voice mechanism must be induced and cannot be forced. On the other hand, interference, being under the control of the will, can be eliminated.

XIX. The principal business of the voice teacher is to develop the voice.

XX. Voice development consists in the development of the vocal muscles.

XXI. The principles of muscular development require alternate contraction and relaxation without strain. Short tones give the alternate contraction and relaxation required for the development of the vocal muscles. Removal of interference eliminates strain; hence, short, soft tones without interference form the ideal exercise for voice development.

XXII. The laws which regulate voice production are precisely the same in every singer and speaker.

XXIII. Every mechanism which produces the voice is exactly similar. It is composed of the same elements—vocal cords, muscles and cartilages of the larynx, and resonance cavities.

XXIV. All vocal cords are of the same material—yellow elastic tissue.

XXV. In correct voice production, the action of the muscles and cartilages of the larynx is precisely the same in every individual.

XXVI. Those conditions which give full use of the resonance space are identical in every speaker and singer.

XXVII. Differences in the size and shape of the elements of the voice mechanism account for individual characteristics of voices.

XXVIII. The art of singing is composed of two elements, viz., the art of voice production and the art of interpretation.

XXIX. The art of voice production is based upon the facts of anatomy, physiology, and physics. These facts apply to every voice mechanism with equal force and in precisely the same way, and are therefore impersonal.

XXX. The art of interpretation is based upon the personal experience, knowledge, musical taste and feeling of the singer, and is therefore individual.

XXXI. This being true, it is evident that the art of voice production may be standard-

ized, as the same set of facts may be used to measure the product of every mechanism.

XXXII. It also follows that the art of interpretation cannot be standardized, as each singer's interpretation is based upon a different set of facts.

XXXIII. As there is but one set of facts underlying the art of voice production, there can be but one standard method, and this must conform in every particular to these fundamental facts.

XXXIV. Method in voice development is not only possible, but absolutely essential, while method in interpretation is an impossibility.

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